ARCHAEOLOGY AND ENVIRONMENT IN THE VALE OF YORK

Studies in the use of insect remains in the interpretation of archaeological environments

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In the Soil of all, or most of which the abovesaid 180,000 Acres of Land, of which 90,000 were drained, even in the bottom of the River of Ouse, in the bottom of the adventitious Soil of all Marshland, and round about by the skirts of the Lincolnshire Woulds unto Gainsburg, Bautry, Doncaster, Baln, Snaith and Holden, are found infinite Millions of the Roots and Bodies of Trees of all bignesses great and little, and of most of the sorts that this famous Island either formerly did, or that at present does produce, as Pitch Trees commonly called Firrs, Oaks, Birch, Beech, Yew, Wirethorn, Willow, Ash, & c. the Roots of all, or most of which stand in the Soil in their natural postures, as thick as ever they could grow, as the bodies of most of them lye by their proper Roots. Most of the great Trees, by all their length about a yard from their great Roots (unto which they did most evidently belong, both by their situation, and the sameness of the Wood) with their tips commonly North East, tho indeed the smaller Trees lye almost every way cross those, some above, some under, a 3d part of all which are Pitch Trees, commonly called Firrs, some of which have been found of 30 yards length and above, and have been sold to make Masts and Keels for Ships of. Oaks have been found of 20, 30 and 35 yards long, yet wanting many yards at the small end.

Abraham de la Pryme, 1701.

THORNE MOORS : A PALAEOECOLOGICAL STUDY OF A BRONZE AGE SITE

Introduction

Thorne Waste, or Moors, lies 15 km. north-east of Doncaster, 7 km. south of Goole, Yorkshire. Although reduced in area by drainage and warping in the nineteenth century, it still comprises, with the contiguous bogs of Snaith and Cowick, Goole and Crowle Moors, roughly 21 sq.km. of degraded Sphagnum bog, the largest surviving area of lowland ombrophilous mire in Eastern England (Rogers & Bellamy, 1972). To the south and east, the Moors are bounded by the alluvium of the former main channel of the River Don which, until the drainage in the seventeenth century, flowed eastwards to the Trent at Adlingfleet. The alluvium of the Ouse forms the limit to the north and westwards the deposits of the River Went can be traced beneath the Turnbrigg Dyke, a diversion of the Don of mediaeval or earlier construction (Gaunt, 1975). The present surface of the Moors, after peat cutting, lies at about 2 m. O.D., somewhat below natural high tide level on the surrounding rivers, and, as on much of Hatfield Chase, continuous pumping is necessary to avoid flooding.

Commercial peat cutting operations began in the late nineteenth century and have continued at an increasing rate until the present day, by which time upwards of 4 m. of peat have been removed from the greater part of the surface of the Moors. The primary exploitation by the Dutch used canals and barges to move the peat and these canals, now largely infilled by new growth of Sphagnum have acted as refuges for the plants of the ombrophilous mire complex, in the face of increasing drying out by drainage activities. The canals area, east of the now defunct Thorne Moorends Colliery, thus

has a very diverse acid bog flora and several uncommon species from the fen environment survive on the edges of the warplands. The plant list includes such rarities as Osmunda regalis, Viola stagnina, Drosera spp., Salix repens, Utricularia spp., Menyanthes trifoliata and Andromeda polifolia, for many of which Thorne Moors provide the only locality in the Lowland Zone. Amongst the invertebrates the recent addition of the small Carabid Bembidion humerale Sturm. to the British insect list from Thorne specimens is of particular note (Crossley & Norris, 1975), but reference should also be made to the Mantis fly, Ochthera mantis, a fenland bug Anthocoris limbatus, the Mullein Shark moth, Cucullia verbasci and the Erotylid beetle Triplax russica (Skidmore, 1970).

The present surface of the Moors is largely dominated by birch scrub and bracken in the drier areas and cotton grass in the wetter. Clearance and peat cutting leave a dismal wetland landscape dominated by Eriophorum spp. The amount of habitat disturbance and speed of operation of modern, commercial peat exploitation is so great that, unless urgent conservation measures are taken, the rarer plants and animals will be unable to recolonise the cut-over areas and will become extinct. There have also been several proposals to develop the land, ranging from an airfield to the disposal of power station waste.

Previous Research

In many ways, the Hatfield Levels provide an ideal area for palaeoecological study. Useful primary references to the flora go back to Leland (1543) and Gerarde (1597). The papers and diaries of the Reverend Abraham de la Pryme (1687-1703), vicar of Hatfield, contain numerous notes on local topography and the peat deposits. Information can also be gleaned from Stovin (1730), Peck (1815),

Figure 56. Thorne Moors : before peat cutting (1975)

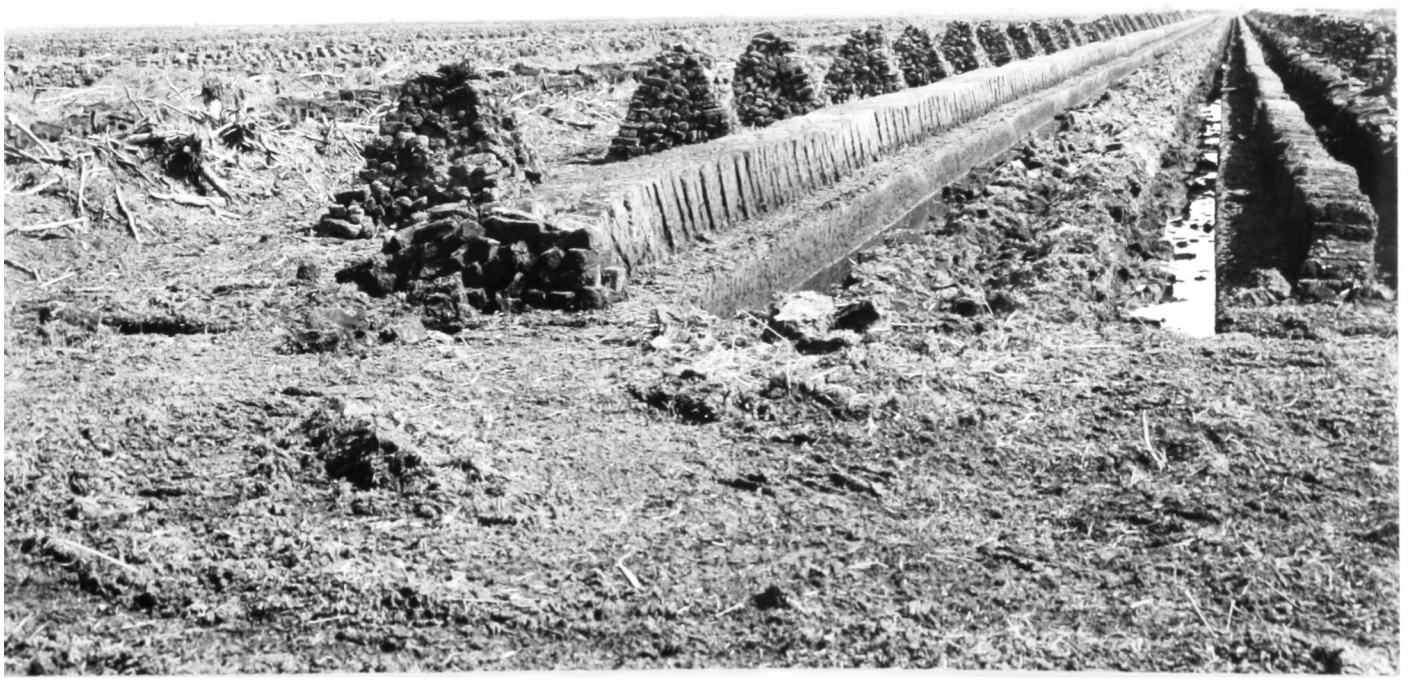

Figure 57. Thorne Moors : after peat cutting (1975)

Casson,(1829) and Stonehouse (1839). The ecology of Thorne Moors in particular, as it was and had been was reviewed by Peacock (1920-21) and, more recently by Skidmore (1970). The threat to the Moors created by the proposed dumping of 32 million tons of pulverised fuel ash by the Central Electricity Generating Board in 1969, spurred local naturalists, led by W. Bunting of Thorne, into preparing a detailed list of the flora and fauna of Thorne Moors (Bunting et al., 1969). These lists, with additions made since 1969 by the staff of Doncaster Museum, provide a usefully detailed modern background on which to base any palaeoecological study of the peats and other deposits underlying the Moors.

Although Leland (1543) refers to "firre trees overthrown and coverid with bogge and mershe" (Gorham, 1953) on the Isle of Axholme, the first paper devoted to the fossil material and consideration of its origin in the Hatfield Levels was written by de la Pryme and published in the Transactions of the Royal Society in 1701. In much quoted, often misquoted passages (Tomlinson 1882; Rogers & Bellamy 1972), de la Pryme notes the occurrence of 'pitch trees', oak, birch, beech, yew, 'wirethorn', willow, ash and hazel beneath the peat. In a later contribution he suggests that a few 'pitch trees called firrs', referring to the Scots pine, lasted into the eleventh century and finally disappeared shortly before the drainage (de la Pryme, 1704). The destruction of this forest he attributed to the Romans under Ostorius Scapula in the first century A.D. Whilst this hypothesis can now be seen as little more than antiquarian speculation, his reference to the finding of worked wood and metalwork with coins of Vespasian during the cutting of a new river, presumably the Dutch River, may, in a circumstantial manner,

have some bearing on the date of construction of the Turnbrigg Dike, which lies west of the Moors. As well as de la Pryme's accounts of finds of artifacts in the peat (above p. 156) and of a preserved body from Thorne Moors, Stovin (1747) records the body of a woman in an upright posture from the peat at Amcotts, near Althorpe on the Trent. Later antiquarians, particularly Tomlinson (1882), add little original data and consist largely of plagiaries of de la Pryme and Stovin.

Pollen analysis on the deposits of the Hatfield Levels was first carried out by Erdtman (1928), who concluded that peat formation began late in the Atlantic period (pollen zone VII(a)). His work was expanded by Pigott (1956), although the diagrams were never published. Pigott notes evidence for cereal cultivation going back to the Early Bronze Age (zone VII(b)) from Thorne Moors and equates the silts and clays beneath the peat with the transgressive, Late Neolithic 'Buttery Clay' of the Cambridgeshire Fens (Godwin, 1940). Subsequent research has shown that these deposits belong to the terminal phases of the Last Glaciation (Gaunt, 1974; below p. 172). Pigott, however, was correct in assigning the peats of Thorne Moors to the upper part of pollen zones VII(b) and VIII. The dangers of assuming contemporaneity between two adjacent bogs are illustrated by Rogers and Bellamy's (1972) use of Smith's (1958) data from Hatfield Moors in their discussion of Thorne. Hatfield Moors is separated from Thorne by only 3 km. of alluvium and Late Glacial sands yet peat deposition there began considerably earlier during zone VII(a) (Smith, 1958). Smith's work provided useful background to the archaeology of the region and his interpretation of the evidence, showing increasing agricultural activity through the Iron Age with a maximum in the Roman period has been amply confirmed by recent aerial photography

(below p.302 & figs. 86 & 87) and excavations at Dunsville, 5 km. west of Hatfield (Magilton & Dolby, in prep.), and Sandtoft, between the two moors (Samuels, in prep.). Smith also refers to unpublished diagrams by Clapham (op. cit.). In a similar doctoral thesis for the University of Cambridge, Turner (1960) prepared detailed diagrams from Thorne Moors and parts of these have been published in her work on forest clearance (Turner, 1962; 1965). The provision of ^{14}C dates considerably enhanced the value of these pollen diagrams by providing a firm chronological framework. Samples from near the base of the succession gave dates of 3,160 ± 115 B.P. (Q.481) and 2,931 ± 115 B.P. (Q.482) and these correlate well with those obtained during the course of this research. Also relevant to the interpretation of the Thorne Moors sites is the remapping of the Drift deposits of the Doncaster and Goole districts for the Institute of Geological Sciences, principally by Gaunt (Gaunt et al., 1971; Gaunt, 1974; 1975).

The Archaeological Evidence

During October 1971, William Bunting, a local naturalist with considerable knowledge of the Moors, reported to both Doncaster Museum and the author that several large trees with charred surfaces had been thrown up during the cutting of a major new drain across the Moors, through the Canals region and draining into Thorne Waste Drain, flowing south-eastwards along the eastern edge of the warplands of Tween Bridge Moors, towards Elmhirst Cottage. Bunting had reported similar, more extensive finds around Medge Hall, at the southern tip of the Moors in 1949, but no archaeologist had followed up the finds and they passed unnoticed except in the local press (Yorks. Evening News, 6.1.49). In Doncaster Museum, there exists correspondence with Leslie Armstrong about several rather undiagnostic flints from the

region of Elmhirst Cottage, which suggests that these, now lost pieces might have been of Bronze Age date. A local farmer, John Birtwhistle, had also recovered a few artifacts, including a fine tranchet axe (above p. 154) and a perforated stone battle axe (Dolby, 1969) from the sand ridge on which Whitaker's Plantation stood, between Thorne and Nun Moors. All these finds had apparently come from beneath the peat. In view of this material, de la Pryme's account (1701) and Turner's (1965) pollen analytical evidence from the peat for small, temporary clearances in local woodland during the Late Bronze Age, it was decided that Bunting's findings warranted investigation. The lengths of new drain along which the burnt timbers occurred were recorded and samples taken for both faunal investigation and radio-carbon dating. On a subsequent visit, three large, apparently split timbers were noted lying side by side close to the base of the peat and a very limited excavation, undertaken principally to recover samples for faunal analysis, during June 1972, revealed a short stretch of a rough trackway, constructed of timbers of various sizes, orientated approximately south east to north west (fig. 61). Since the level of the structure lay largely below that of current peat extraction operations and resources were limited, it was decided that no further fieldwork was warranted on the site and research was restricted to the examination of soil and wood samples and the preparation of an outline pollen diagram.

The principal area in which burnt timbers occurred lay between the second and third canal, c. 400 m. south of the footpath which runs out onto the Moors parallel with Cottage Dike, virtually due east of the end of the spoil heap of Moorends Colliery (site centred on N.G.R. SE721153). Along this stretch of the new drain, the mechanical grab had torn up many pieces of tree trunks, several

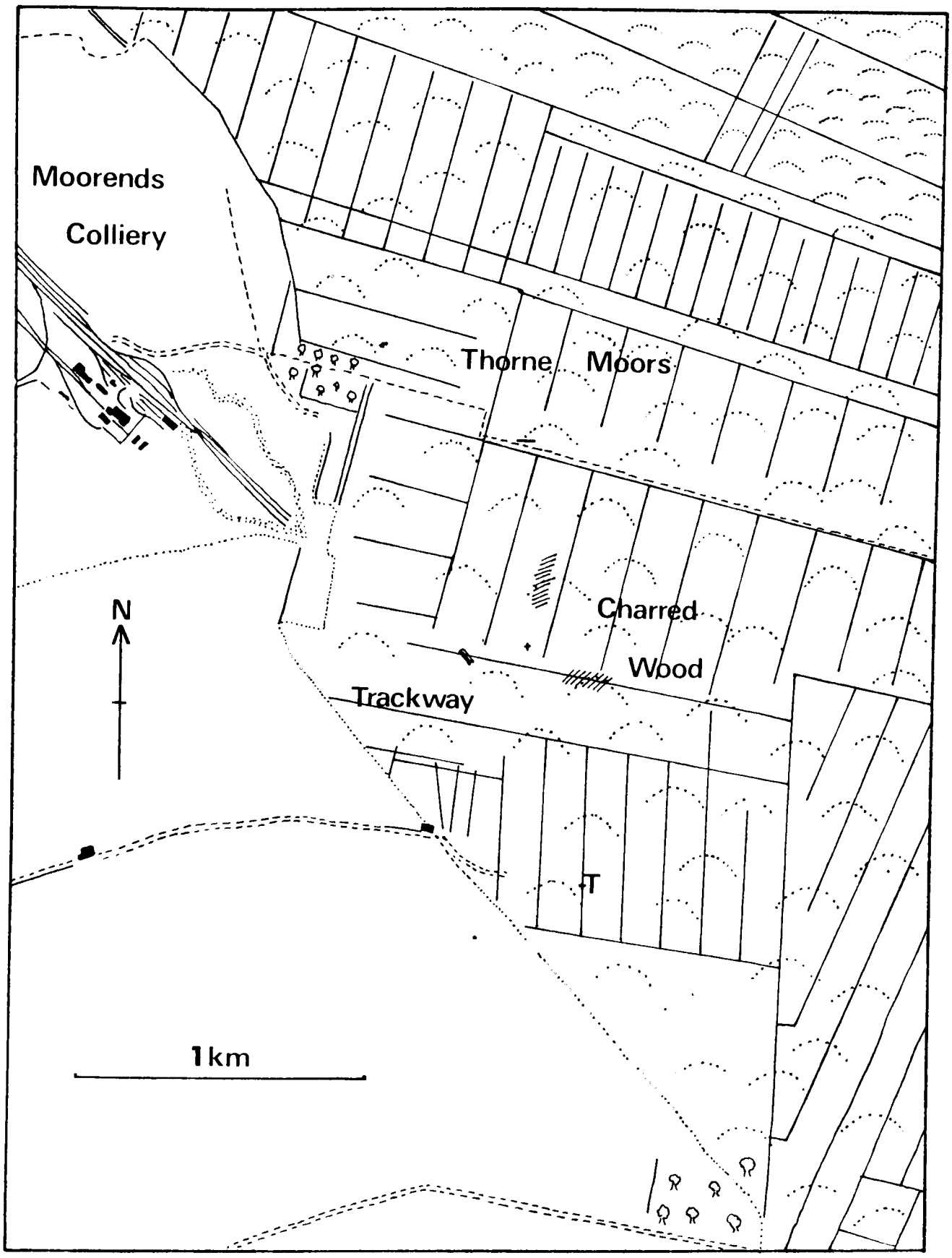

Figure 58. Thorne Moors : location of sites investigated. (the small cross between the two areas of charred wood denotes 'tree 1' where samples 3 & 4 were recovered. 'T' marks the approximate position of Turner's pollen samples.)

of which had the surfaces charred to depths in excess of 1 cm. The bark was missing from these fragments, the largest of which were of the order of 2 m. long and o.5 m. across. The level of water in the drain made closer examination of the trees in situ difficult and several complete, apparently unburnt trunks, which the grab had failed to cut through, further impounded the drainage. It was apparent, however, that all the large trees lay close to or at the base of the peat, here about 1.75 m. thick, and the upright stumps of several were still clearly rooted in the underlying deposits. Excavation was impractical and, in any case, on a limited scale, liable to yield little additional information since the burnt fragments were scattered over about 50 m. of the length of the dyke. One of the superficially charred pieces of tree was recovered and the charcoal stripped from the surface and submitted for a radiocarbon date. The wood, subsequently identified as oak, provided a date of 3080 $\pm$ 90 B.P. (Birm. 336).

The second area with burnt timbers lay in a drain cut at right angles to the first area, roughly 400 m. further south (centre of area at N.G.R. SE722149). This cut produced fewer obvious fragments of burnt tree trunks and these were dispersed along about 100 m. of drain. Examination of the deposit in situ was again almost impossible but it was evident that the material came from the base of the peat. It seems probable that both areas relate to the same or two closely related episodes but, because of the alignments of the new drain cuts and the disturbance between to a depth of at least 3 m. by one of the late nineteenth century canal cuts, the two sections cannot be directly stratigraphically related. It is tempting to relate these fires to the first of Turner's (1965) [illegible] horizons, dated to before 3160 $\pm$ 115 B.P. or 2931 $\pm$ 115 B.P. (Q481-482), but recent work on the

incidence of natural forest fires in North America (Brown & Davis, 1973) urges caution. Turner's pollen core site lies less than 800 m. south of the second locality and the sequence may go back sufficiently far to record this event but the difference in altitude between the two sites can only be a few centimetres and tree growth on both sites must have ceased due to waterlogging at about the same time. The preservation of organic deposits must postdate the actual burning since it is improbable that fire would run easily through a moribund forest standing in water and fen peat (below p.202). It is more probable that Turner's diagram relates to clearance on the marginally higher sand and alluvium on either side of the former course of the River Don across the High Levels towards Sandtoft, south of Thorne Moors. Evans (1975) has commented that there is little evidence for the use of burning for clearances from the British Isles, the only example which he is able to cite being from ApSimon's excavations at Ballynagilly in County Tyrone, Ireland. Recent ^{14}C dates, however, suggest that Dimbleby's apparently Mesolithic clearance, phase represented by charcoal in the soil profile at White Gill on the Yorkshire Moors (Dimbleby, 1962), is in fact Late Bronze Age (Jacobi, pers. comm.). It may also be questioned whether one would expect charcoal from landnam in the deposits from which pollen diagrams are most frequently constructed since these largely organic, waterlogged deposits would not be suitable for agriculture and charcoal would only arrive there by redeposition, or the chance firing of the bog surface, a not infrequent occurrence at the present day. Smith (1958) obtained charcoal from samples close to the zone VII(a)/(b) boundary on Hatfield Moors.

Westwards along the new drain, at about 400 m. from its confluence with Thorne Waste Drain, the previously mentioned, possible

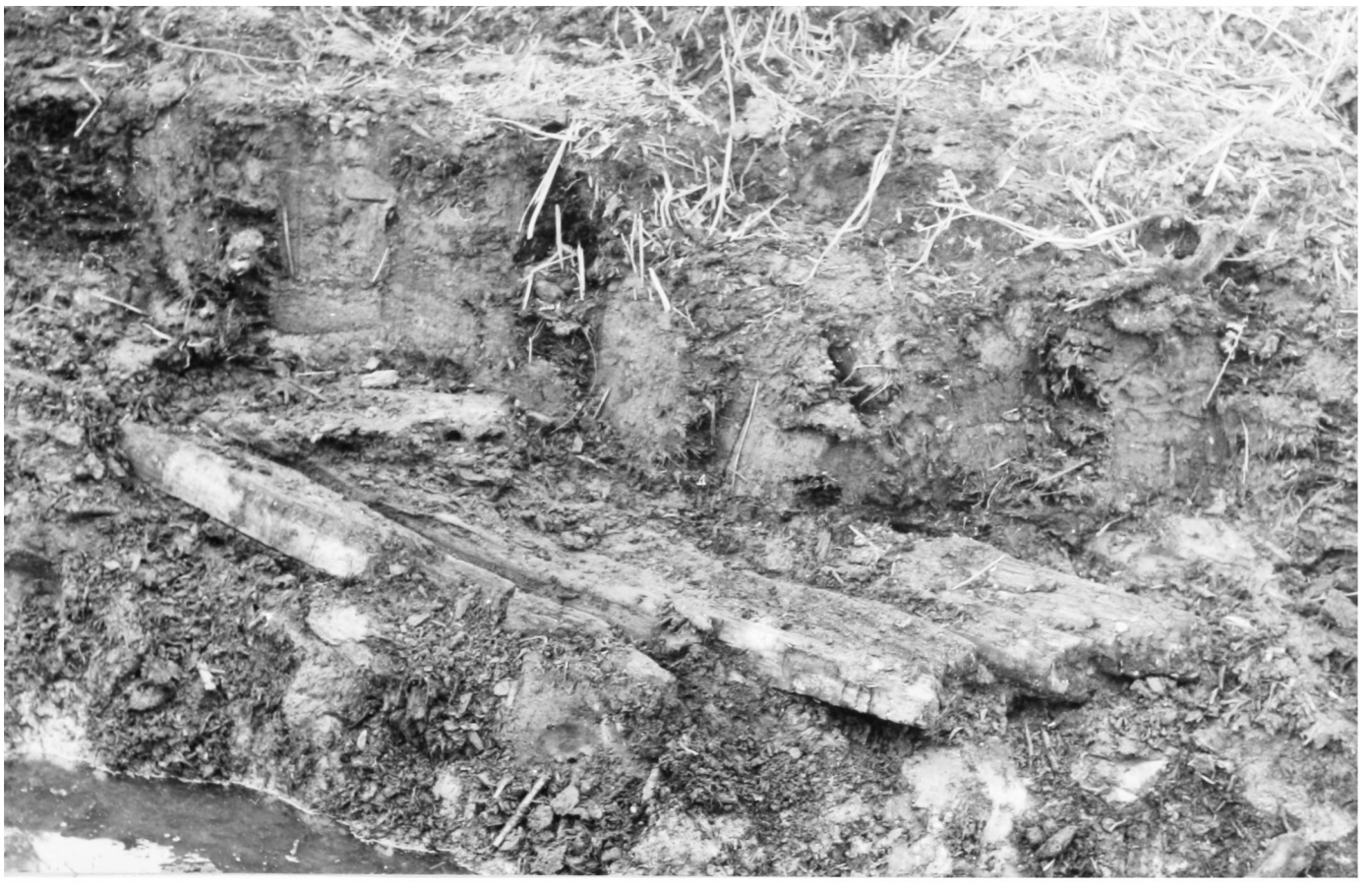

Figure 59. Thorne Moors : the trackway as initially exposed.

Figure 60. Thorne Moors : the trackway.

trackway was noted protruding from the south section of the dyke (at N.G.R. SE726151). The disturbance of the north bank made it evident that the grab had dragged similar timbers from that side and these lay on the spoil heap. Although timber is frequent at the base of the peat, the attitude of these pieces was suggestive of a man-made structure and it was decided to excavate a short section to investigate this. An area 6 m. long by 1 m. deep was cut back from the ditch side and a further 1m. square cut beyond it to ascertain any alignment. The peat, here surviving to a maximum depth of 1.0 m., was removed down to the surface of the timbers and these were roughly cleaned up. Seven split timbers were located lying side by side, providing a slightly undulating surface, remaining to a maximum width of about 3 m. (fig.61). The surface of the wood was poorly preserved, largely reduced to a soft amorphous structure, and some of the timbers had been split and partially pulled out of place by the drag. Several smaller pieces and thin trunks lay at various angles, in a horizontal position, over the main surface. There was no evidence in the small area examined for the extensive use of coppiced timber which has been shown to be used in the construction of some of the Somerset trackways (Coles& Orme, 1976), and most of the timbers clearly came from the trunks of trees which were moribund or dead before incorporation in the structure. Although the outer surface of the wood remained, the bark was absent from most and several were obviously extensively bored by insects. Some lengths of birch, however, retained the bark and the bark was removed from a small pine, about 15 cm. in diameter, lying across the larger timbers, to provide the sample for the radiocarbon date of 2980 $\pm$ 110 B.P. (Birm. 358). Although several timbers appeared to show oblique chop marks (fig.59), none was sufficiently convincing to be wholly acceptable and no artifacts were recovered from the site. Peat cutting over the area south of this feature had

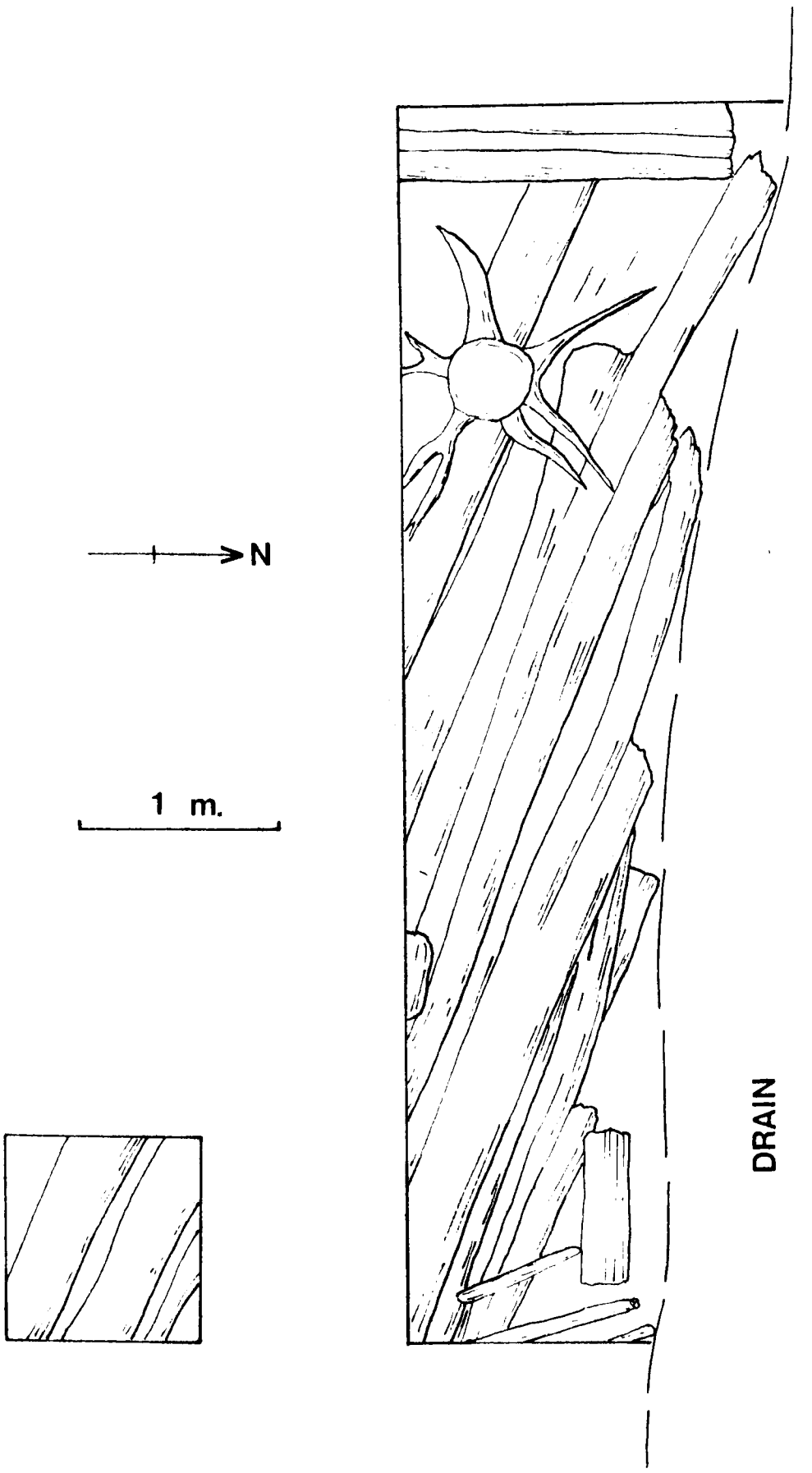

Figure 61. Thorne Moors : plan of the trackway.

penetrated to within 30 cm. of the horizon but no further timbers were apparent. Despite the absence of corroborative material and the limited nature of the excavation, there can be little doubt that the structure represents part of a crude trackway, orientated roughly north west to south east. The timbers may only represent a minor feature, across a marginally damper area, but, on this alignment, such a track could have connected the slightly higher and drier areas of Pighill Moors, where Moorends Colliery now stands, and Medge Hall, although the actual topography beneath peat and warp is difficult to ascertain. Similar trackways are widely known, particularly in the Somerset Levels (Coles & Hibbert, 1975). The irregular nature of the excavated fragment may, however, be misleading. The Neolithic Sweet Track on the Somerset Levels (op. cit.) has a complex irregular deposit of timbers put down into an open water part of the bog to support a level single plank walkway, and a similar upper structure may not have survived at Thorne. In the Fens, mediaeval roads were kept in repair by means of bundles of rushes and reeds, a method still used into this century to deal with thick, black peat mud (Porter, 1969), and the actual surface may not have been preserved at Thorne, although such material might be expected to be reflected in the insect faunas. The whole structure and concept is reminiscent of how Stephenson coped with Chat Moss in providing a firm footing for the Liverpool and Manchester Railway (Smiles, 1854), and his bundles of brushwood would no doubt look very similar and disordered if excavated. No other trackway has yet been recorded from the Hatfield Levels but a much better constructed one, with squared timbers, is recorded from the Ancholme Valley at Brigg in North Lincolnshire belonging to the end of the Late Bronze Age or Early Iron Age (Dudley, 1949; Smith, 1958). The two carbon dates, supplemented by a third of 3260 ± 100 B.P. (Birm. 335) from a rootlet

of a birch seated on the underlying deposits, fall towards the end of the Middle Bronze Age (Burgess, 1974).

There are few artifacts of the last two phases of the Bronze Age from Hatfield Chase and only a few sherds from a site near Crowle of the succeeding Iron Age (fig. 88). No finds of pottery occur closer than the collared urn from Doncaster (Manby, 1973) and there are, as a result, no proven occupation sites. No securely localised bronze implement can be related to any site catchment orbit which might be drawn to include the trackway site, based upon the 5 km. radius suggested as the mean maximum distance from the settlement site for a sedentary agricultural community (Chisholm, 1968), but since the feature does not relate directly to land exploitation, the trackway could connect two more distant settlements. Amongst the incompletely localised material, however, an adze palstave comes from the Sandtoft region (Davey, 1973, no. 39), an area shown to have been extensively cultivated at least by the Roman period (fig. 86), and a palstave is recorded from Moorends parish, 2 km. to the west of the site. Other Middle Bronze Age finds from the Chase include a palstave from Misson, a rapier from Austerfield and a looped, socketed spearhead from Hatfield. A gold torc from Low Burnham, on the Isle of Axholme, is in the British Museum. From Finningley come two Late Bronze Age socketed axes and a rivetted, socketed spearhead and a socketed axe is known from Hatfield Woodhouse; a basal looped, socketed spearhead has been found near Hatfield. A hoard of Middle Bronze Age equipment was alleged to have been found in 1747 near Crowle (Dudley, 1949), but a recent re-examination of sources suggests that the hoard in fact comes from Burringham on the other side of the Trent (Knowles, pers. comm.). A further hoard was found during the construction of Keadby Bridge over the Trent early this century (Davey, 1973). As was apparent on the Misterton Carr site, it is evident that much must remain buried beneath

The Geological Sequence

In all the sections exposed in the ditch sections, about one metre of peat remained over a gently undulating surface of poorly sorted, light grey sandy silt. Up to 0.5m. of these silts were exposed in the base of the dykes and, although much disturbed, in some cases by tree roots surviving from the overlying brushwood peat horizon, some trace of thin, horizontal bedding was evident. Occasional pellets of red marl of Permo-Triassic origin occurred and, from one section, a large, angular block of Millstone Grit, weighing c.15 kg., was recovered. At Sandtoft (SE734090), a more complete section through these deposits showed a similar leached silt horizon, underlain by chocolate-brown laminated clays, the 'Silt and Clay' of the '25-Foot Drift' of the geological maps (Gaunt et al., 1971). The presence of a block of coal, 15 cm. by 15 cm. by 10 cm. in the layer at Sandtoft, with the gritstone erratic from Thorne Moors, implies transport by ice, probably in icebergs floating in the proglacial Lake Humber, and these strata are interpreted as marking the terminal phase of the lake (op. cit.; Gaunt, 1976), dated to before 11,100 B.P. The correlation between the two localities, however, is not irrevocable. A thin, compressed peat, overlying the silts at Sandtoft, produced an undiagnostic insect fauna, yet to be examined in detail, which suggested a Carex marsh environment with no trees in the immediate vicinity. This could relate to either pollen zone I of the Late Glacial or the immediately post-Cover Sands zone III/IV boundary, before the immigration of woodland. Since this layer is cut through by an at least three metre thick succession of silts filling the old bed of the river Idle and is overlain by nearly two metres of thinly bedded sands, it is tempting to relate these beds to the 'Older fluvial depositional phase' of Gaunt et al. (1971) and to

correlate the thin bedded sands with similar deposits, mapped as 'older Blown Sand' on the Doncaster sheet, north of the old course of the Don, on the southern margin of Thorne Moors. In support of this interpretation, it can be noted that brown, silty clays were located by augering at the western tip of the Moors, east of the colliery (SE711161).

The soil horizon which underlies the Flandrian peat deposit is of some interest since rarely do the silts of the '25-Foot Drift' preserve a soil profile at the present surface. To the east, extensive outcrops of Cover Sands, in part derived from these deposits, (above p. 7), are strongly podzolised (Straw, 1969) and, from the truncated profiles examined at the surface on the Chase, it is apparent that the more silty parts of the Lake Humber sediments would also bear podzols at the present day. A soil, sealed beneath an undated post-Glacial dune at Messingham, however (above p. 17), would be better described as a 'sandy brown earth' (after Straw, 1969) and the Thorne Moors substrate, where the organic component has been preserved by waterlogging, shows an incompletely developed podzol. The rising water table, which has resulted in this preservation, however, complicates interpretation. No iron pan or zone of iron deposition occurs in the profile and the interface between peat and silt is represented by a moder rather than a mor humus with some intermixing of silt and organic component, presumably by arthropod rather than worm action. Pollen from the upper few centimetres of silt was poorly preserved but showed a mixing of the woodland spectrum with a few grains of juniper, presumably surviving from initial deposition during the Late Glacial or pollen zone IV. The survival of pollen through the period of afforestation in the early post-Glacial into the Bronze Age is surprising and suggests that the soil, at least

in this locality, had always been deficient in bases, leaching perhaps having occurred during the period of heavy snowfall and, consequent high runoff in pollen zone III (above p. 64). Despite the enascent podzol, when peat deposition began, it was in a fen rather than acid bog environment. The terminal phase of the last glaciation was marked by deep incision of water courses towards a sea level of at least -16m. O.D. (Gaunt & Tooley, 1974), and organic deposits are therefore lacking until the water table became sufficiently high to facilitate preservation. On Hatfield Moors, peat deposition began during pollen zone VII(a) (Smith, 1958) and at Thorne Waterside, sediments in the channel of the old Don have been dated to 4230±100 B.P. (Birm. 359). On Thorne Moors, although there may be pockets of slightly earlier deposition, a brushwood peat had begun to form by c. 3260±100 B.P. (Birm.335), with fen peat giving way to more acid Sphagnum peat and the inception of the raised bog shortly after the trackway horizon of c. 2980±110 B.P. (Birm. 358). In the section at the trackway site(fig. 66), 30cm. of brushwood peat and trackway are succeeded by 70cm. of Sphagnum peat, the upper 20cm. of which is well humified and pollen is not preserved in it.

The Samples

During the examination of fragments of timber thrown out by the dragline cutting the new ditches and the excavation of the trackway, it became apparent that insect remains were particularly well preserved in the brushwood peat at the base of the succession and several near complete individuals were recovered from within wood samples (figs.fro.& 64). 5kg. samples were taken of the dark brown, well humified peat from between the timbers of the trackway (fig. 60) (Sample 2), and from the rather mixed silt and humified peat horizon below the trackway, which represented the moder humus horizon of the

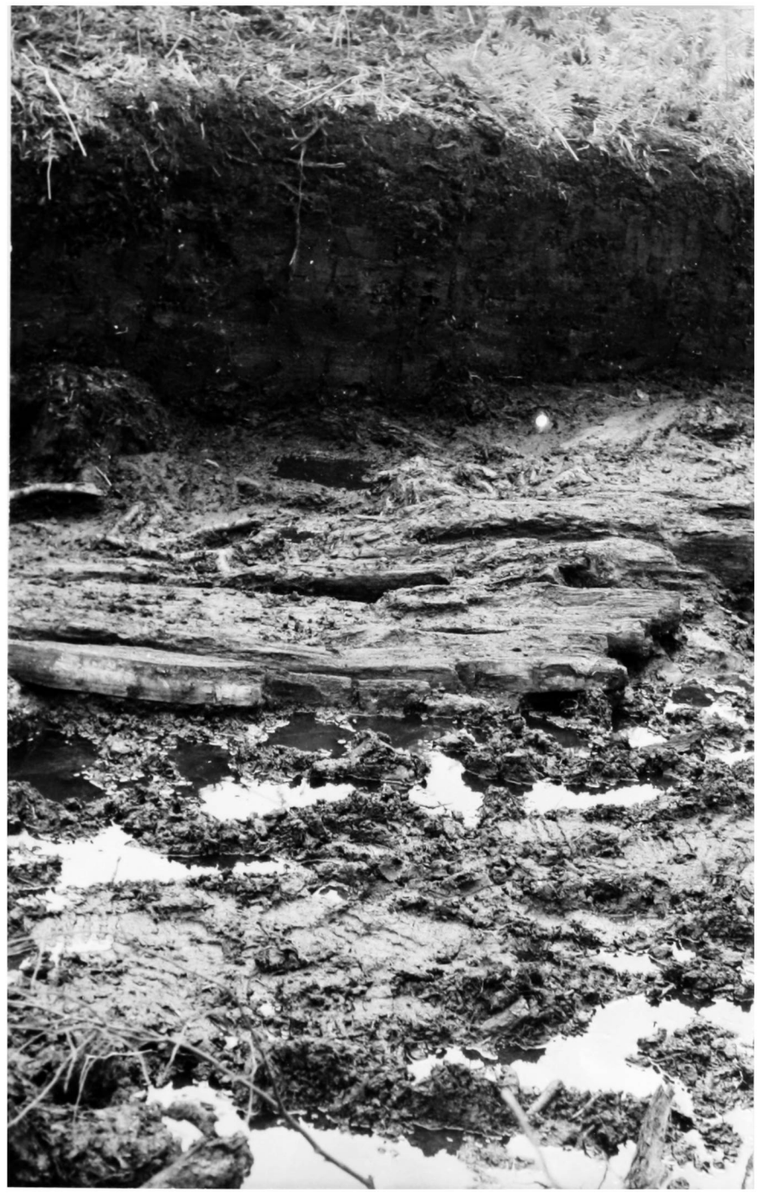

Figure 62. Thorne Moors : trackway.

Figure 63. Thorne Moors : sampling locality 'tree 1'.

soil (Sample 1). A further 10 kg. were taken from an horizon at the base of the Sphagnum peat, roughly 10 cm. above the trackway (Sample 5). Definition of the primary horizon and collection of uncontaminated samples from the two areas, which produced charred timbers were impractical because of the water level in the dykes and it was decided that more useful data could be obtained from the examination of the fauna associated with one of the stools of large trees remaining in situ at the base of the peat. A large stool, subsequently identified as oak, was chosen, lying on the west side of the new north-south dyke close to its junction with the east-west one (N.G.R. 720151)(fig. 58), between the two areas which had produced the burnt wood. This stump (fig. 63), nearly 2 m. in diameter, had well developed buttressing and the peat lying between two of these was cleaned off and sampled in two spits, each weighing c. 5 kg. (the upper, Sample 4 and the lower, Sample 3). Additional material was recovered by splitting wood samples and washing out rot-holes in timbers from various points along the new cut and this material is included in column 6 in the lists of insect remains (table 8). In order to relate the local environment to the more regional picture presented by previous palynological work, pollen counts were prepared by Dr. M. Herbert-Smith utilising samples taken at 10 cm. intervals from the present ground surface down through the trackway in to the underlying silt deposits, to a total depth of 1.5 m. (pollen samples 1 - 15), from which the diagram (fig. 66) and table (9) were drawn up. Sample 1 for insect remains comes from the same horizon as pollen sample 4, the trackway (insect sample 2) is equivalent to pollen sample 6 (fig. 66) and insect sample 5 lies around pollen sample 8.

The samples recovered for insect remains were disaggregated over a 300 micron sieve and the material retained on the sieve placed in a bowl and treated with paraffin (kerosene) (Coope & Osborne, 1968).

soil (Sample 1). A further 10 kg. were taken from an horizon at the base of the Sphagnum peat, roughly 10 c . above the trackway (Sample 5). Definition of the primary horizon and collection of uncontaminated samples from the two areas, which produced charred timbers were impractical because of the water level in the dykes and it was decided that more useful data could be obtained from the examination of the fauna associated with one of the stools of large trees remaining in situ at the base of the peat. A large stool, subsequently identified as oak, was chosen, lying on the west side of the new north-south dyke close to its junction with the east-west one (N.G.R. 720151)(fig. 58), between the two areas which had produced the burnt wood. This stump (fig. 63), nearly 2 m. in diameter, had well developed buttressing and the peat lying between two of these was cleaned off and sampled in two spits, each weighing c. 5 kg. (the upper, Sample 4 and the lower, Sample 3). Additional material was recovered by splitting wood samples and washing out rot-holes in timbers from various points along the new cut and this material is included in column 6 in the lists of insect remains (table 8). In order to relate the local environment to the more regional picture presented by previous palynological work, pollen counts were prepared by Dr. M. Herbert-Smith utilising samples taken at 10 cm. intervals from the present ground surface down through the trackway in to the underlying silt deposits, to a total depth of 1.5 m. (pollen samples 1 - 15), from which the diagram (fig. 66) and table (9) were drawn up. Sample 1 for insect remains comes from the same horizon as pollen sample 4, the trackway (insect sample 2) is equivalent to pollen sample 6 (fig. 66) and insect sample 5 lies around pollen sample 8.

The samples recovered for insect remains were disaggregated over a 300 micron sieve and the material retained on the sieve placed in a bowl and treated with paraffin (kerosene) (Coope & Osborne, 1968).

Table 8 Insect remains from Thorne Moors.

Key

1. soil beneath trackway.
2. between the timbers of the trackway.
3. 'tree 1', lower sample.
4. 'tree 1', upper sample.
5. base of Sphagnum peat, c.10cm. above trackway.
6. additional material obtained by splitting timber.

TABLE 8 INSECT REMAINS FROM THORNE MOORS

	1.	2.	3.	4.	5.	6.
Dermaptera						
Forficulidae						
Forficula auricularia L.	-	-	1	-	-	-
Thysanoptera						
Phlaeothripidae						
Megathrips lativentris (Hieg.)	-	-	-	1	-	-
Hemiptera						
Heteroptera						
Cynidae						
Sehirus biguttatus (L.)	-	-	1	-	-	-
Lygaeidae						
Drymus sylvaticus (F.)/*ryei* Doug. & Scott.	-	-	2	5	-	1
D. brunneus (Sahl.)	2	4	2	-	-	-
Drymus sp. (? *latus* Doug. & Scott.)	-	1	2	1	-	-
Tingidae						
Acalypta parvula (Fall.)	-	-	-	1	-	-
Anthocoridae						
Anthocoris sp.	-	-	-	1	-	-
Miridae						
Globiceps sp.	-	-	-	1	-	-
Saldidae						
Saldula sp.	-	-	-	2	-	-
Chartoscirta cocksi (Curt.)						
Chartoscirta sp.	-	2	1	-	-	-
Corixidae						
indet.	-	not	counted			
Homoptera						
indet.		not	counted			
Ulopidae						
Ulopa reticulata (F.)	-	-	-	-	1	-
Cixiidae						
Cixius nervosus (L.)	-	-	-	1	-	-
Megaloptera						
Sialidae						
Sialis sp.	-	-	-	1	-	-
Raphidiidae						
Raphidia notata F.	-	1	-	-	-	-

Coleoptera	1.	2.	3.	4.	5.	6.
Carabidae						
Leistus terminatus (Hell.)	-	1	1	1	-	-
Nebria degenerata Schauf.	-	-	-	1	-	-
Dyschirius globosus (Hbst.)	1	-	-	-	-	-
Bembidion doris (Panzer)	1	2	1	-	-	-
Bembidion sp.	-	-	1	-	-	-
Trechus secalis (Payk.)	-	1	-	-	-	-
T. quadristriatus (Schr.)/obtusus Er.	-	-	-	1	-	-
Bradycellus ruficollis (Steph.)	-	1	2	14	-	-
B. harpalinus (Serv.)	-	-	1	2	-	-
Trichocellus cognatus (Gyll.)	-	-	-	1	-	-
T. placidus (Gyll.)	-	1	-	-	-	-
Amara (?) familiaris (Duft.)	-	1	-	-	-	-
Stomis pumicatus (Panz.)	-	1	-	-	-	-
Feronia nigrita (F.)	-	5	2	3	1	-
F. minor (Gyll.)	-	13	-	-	-	-
F. strenua (Panz.)	-	9	-	-	2	-
Feronia sp.	-	-	-	1	-	-
Agonum livens (Gyll.)	-	1	-	-	-	-
A. obscurum (Herbst.)	-	2	-	-	-	-
A. fuliginosum (Panz.)	-	11	3	2	-	-
A. gracile (Gyll.)/thoreyi Dej.	-	4	-	-	-	-
Agonum sp.	-	-	1	-	-	1
Rhysodidae						
*Rhysodes sulcatus F.	-	-	-	1	-	-
Haliplidae						
Haliplus sp.	-	1	-	1	-	-
Dytiscidae						
Hygrotus inaequalis (F.)	-	2	-	-	-	-
Hydroporus dorsalis (F.)	-	1	-	-	-	-
H. scalesianus Steph.	-	17	-	-	-	-
H. neglectus Schaum.	-	-	-	2	-	-
H. angustatus Sturm	-	-	-	2	-	1
H. palustris (L.)	-	1	-	-	-	-
H. rufifrons (Muell.)	-	1	-	-	-	-
H. memnonius Nic.	-	1	-	2	-	-
Hydroporus spp.	-	51	19	20	2	3
Agabus paludosus (F.)	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
A. unguicularis Thoms.	-	2	-	-	-	-
A. prob. unguicularis Thoms.	-	17	4	2	-	-
A. bipustulatus (L.)	-	2	1	1	-	-
A. congener (Thun.)	-	-	-	1	-	-
Ilybius (?) quadriguttatus (Lac.)	-	-	-	1	-	-
I. guttiger (Gyll.)	-	1	-	-	-	-
I. prob. guttiger (Gyll.)	-	2	-	-	-	-
Ilybius sp.	-	4	-	-	-	-
Colymbetes fuscus (L.)	-	1	-	-	-	-
Copelatus haemorrhoidalis (F.)	-	1	1	-	-	-
Rantus sp.	-	-	-	-	-	2
Hydrophilidae						
Ochthebius sp.	-	1	-	2	-	-
Hydraena riparia Kug.	-	3	-	-	-	-
Limnebius truncatellus Thun./papposus Muls.	-	1	-	-	-	-
L. nitidus (Marsh.)	-	-	-	1	-	-
Helophorus aquaticus (L.)/grandis Ill.	-	1	-	-	-	-
H. minutus F.	-	-	-	1	-	-
H. granularis (L.)	-	1	-	-	-	-
H. flavipes F./obscurus Muls.	-	-	-	1	-	-
H. (?) obscurus Muls.	-	-	-	1	-	-
Helophorus sp.	-	1	-	1	-	-
Hydrochus brevis (Hbst.)	-	6	-	-	-	-
Coelostoma orbiculare (F.)	-	2	1	1	4	-
Cercyon convexiusculus Steph.	-	22	1	1	-	-
Cercyon sp.	1	-	-	-	-	-
Megasternum obscurum (Marsh.)	1	1	13	1	-	-
Hydrobius fuscipes (L.)	-	5	1	1	-	-
Anacaena globulus (Payk.)	-	28	1	9	-	2
Helochares lividus (Forst.)	-	-	1	-	-	-
Enochrus melanocephalus Ol./testaceus (F.)	-	-	1	-	-	-
E. coarctatus (Gredl.)	-	3	6	6	-	-
Enochrus sp.	-	-	1	-	-	1
Silphidae						
Phosphuga atrata (L.)	1	2	2	-	-	-
Choleva sp.	-	-	4	1	-	-
Catops sp.	-	-	1	-	-	-
Leiodidae						
Agathidium atrum (Payk.)	-	-	1	1	-	-

	1.	2.	3.	4.	5.	6.
A. seminulum (L.)	1	1	-	-	-	-
A. nigrinum Sturm.	-	-	1	-	-	-
Agathidium sp.	-	2	1	-	-	-
Phalacridae						
Phalacrus nigrinus (Marsh.)	-	-	-	-	-	1
Scydmenidae						
Leuranes sp.	-	-	1	-	-	-
Stenichnus collaris Muell.	-	-	-	1	-	-
Stenichnus spp.	-	-	3	1	-	-
Orthoperidae						
Corylophus cassidoides (Marsh.)	1	-	-	-	-	-
Ptiliidae						
Ptenidium nitidum (Heer)	-	-	-	1	-	-
Ptenidium spp.	-	-	3	-	-	-
Acrotrichis prob. intermedia (Gill.)	1	1	7	1	-	-
(?) Pteryx suturalis (Heer)	-	-	1	-	-	-
Staphylinidae						
Metopsia gallica (Koch.)/clypeata (Muell.)	-	-	1	-	-	-
Proteinus ovalis Steph.	-	3	1	3	-	-
P. atomarius Erich.	-	1	-	-	-	-
Phyllodrepa ioptera (Steph.)	-	2	1	-	-	-
P. vilis (Erich.)	-	2	2	-	-	-
Xylodromus depressus (Grav.)	-	10	-	-	-	-
Anthobium unicolor (Marsh.)	-	-	1	-	-	-
Olophrum piceum (Gyll.)	-	9	9	4	-	-
O. fuscum (Grav.)	-	2	-	-	-	-
Acidota crenata (F.)	1	1	1	-	-	-
Lesteva Heeri Fauv.	-	8	-	5	-	-
Syntomium aeneum (Muell.)	-	-	-	3	-	-
Oxytelus fulvipes Erich.	-	1	-	-	-	-
O. rugosus (F.)	-	-	1	-	-	-
O. sculpturatus Grav./mutator Lohse.	-	1	-	1	-	-
Stenus nitidiusculus Steph.	-	3	1	1	-	-
S. juno F.	-	5	-	-	-	-
S. boops Ljungh	-	1	-	-	-	-
S. cicindeloides (Schal.)	-	1	-	-	-	-
Stenus spp.	1	26	3	2	-	-
Euaesthetus ruficapillus Bois & Lac.	-	1	-	-	-	-
Paederus riparius (L.)	-	1	2	1	-	-

	1.	2.	3.	4.	5.	6.
Rupilus rufipes (Germ.)	2	-	2	-	-	-
Medon (?) brunneus (Er.)	-	-	2	-	-	-
Lathrobium longulum Grav.	2	-	4	1	-	-
L. terminatum Grav.	-	2	-	1	1	-
L. rufipenne Gyll.	-	-	2	1	-	-
Lathrobium spp.	4	25	12	4	1	-
Xantholinus (?) linearis (Ol.)	-	-	2	1	-	-
X. longiventris Heer	1	-	-	-	-	-
Ochthephilum fracticorne (Payk.)	-	1	-	-	1	-
Baptolinus affinis (Payk.)	2	2	9	2	-	-
Othius punctulatus (Goeze)	-	1	3	-	-	-
O. myrmecophilus (Kies.)	2	3	10	2	-	-
Othius sp.	-	-	1	1	-	-
Erichsonius cinerescens (Grav.)	-	-	-	-	1	-
Erichsonius sp.	-	-	1	-	-	-
Philonthus nigrita (Grav.)	-	1	-	-	-	-
Philonthus sp.	2	-	-	-	-	-
Quedius fuliginosus (Grav.)/subfuliginosus Brit.	-	-	2	-	-	-
Quedius sp.	-	4	2	-	1	-
Quedius/Philonthus spp.	-	5	-	1	1	-
Habrocerus capillaricornis (Grav.)	-	-	1	-	-	-
Mycetoporus rufescens Steph.	-	-	2	-	-	-
M. splendidus (Grav.)	-	-	1	2	-	-
Bolitobius cingulatus (Mann.)	-	-	-	-	1	-
Conosomus marshami (Steph.)	-	1	1	1	-	-
C. immaculatus (Steph.)	-	-	1	1	-	-
Tachyporus (?) pusillus Grav.	-	-	2	-	-	-
Tachyporus sp.	-	1	2	-	1	-
Deinopsis erosa (Steph.)	-	1	-	-	-	-
Gymnusa brevicollis (Payk.)	-	1	-	-	-	-
G. variegata Kies.	-	-	2	-	-	-
Gymnusa sp.	-	-	-	-	1	-
Autalia rivularis Gr.	-	-	1	-	-	-
A. impressa Ol.	-	1	1	-	-	-
Drusilla canaliculata (F.)	-	-	1	2	-	-
Ilyobates subopacus Palm	-	1	2	-	-	-

	1.	2.	3.	4.	5.	6.
Aleocharinae indet.	-	17	36	5	8	3
Pselaphidae						
Plectophloeus nitidus (Fairm.)	-	-	1	-	-	-
Euplectus sp.	-	1	-	-	-	-
Bryaxis curtisii (Leach)	-	-	2	-	-	-
Bryaxis spp.	1	13	14	3	-	-
Reichenbachia impressa (Panz.)	-	3	2	-	-	1
Pselaphus heisei Hbst.	-	-	1	-	-	-
Histeridae						
Abraeus globosus (Hoff.)	-	1	-	-	-	-
Microlomalus parallelipipedus (Hbst.)	-	1	-	-	-	-
Cantharidae						
Cantharis paludosa Fall.	-	2	-	-	-	-
Rhagonycha lignosa (Muell.)	-	-	-	1	-	-
R. testacea (L.)	-	2	-	-	-	-
Malthodes sp.	-	2	-	-	-	-
Dasytidae						
Haplocnemus pini Redt.	-	1	-	-	-	-
Dasytes niger (L.)	-	1	-	-	-	-
Cleridae						
Thanasimus formicarius L.	-	1	-	-	-	-
Elateridae						
Athous haemorrhoidalis (F.)	-	-	1	-	-	-
A. hirtus (Hbst,)	1	-	-	-	-	-
Elater (?) pomorum (Hbst.)	-	1	-	-	-	-
E. balteatus L.	-	-	-	2	-	-
E. nigerrimus Lac./nigrinus Hbst.	-	2	-	-	-	-
Elater sp.	-	1	1	-	-	-
Melanotus rufipes (Hbst.)	-	-	1	-	-	-
Agriotes pallidulus (Ill.)	1	-	-	-	-	-
Dolopius marginatus (L.)	-	1	4	2	1	-
Denticollis linearis	-	1	1	-	-	-
Eucnemidae						
Melasis burrestoides (L.)	1	1	1	1	-	1
*Isorhipis melasoides (Lap.)	-	-	-	-	-	7
Trixagus carinifrons (Bonv.)	-	1	2	-	-	-
Eucnemis capucina Ahr.	-	-	-	1	-	-

	1.	2.	3.	4.	5.	6.
Dascillidae						
Dascillus cervinus (L.)	-	1	-	-	-	-
Helodidae						
Microcara testacea (L.)/bohemani (Mann.)	-	4	2	-	-	-
Gen. et spp. indet.	6	200+	199	68	54	13
Heteroceridae						
Heterocerus sp.	-	1	-	-	-	-
Dermestidae						
Trinodes hirtus (F.)	-	1	-	-	-	-
Ostomatidae						
*Pelta (Zimioma) grossum (L.)	-	-	-	-	-	1
Thymalus limbatus (F.)	-	2	-	-	-	-
Nitidulidae						
Brachypterus urticae (F.)	-	-	1	-	-	-
Meligethes sp.	-	-	1	-	-	-
Epuraea guttata (Ol.)	-	1	-	-	-	-
E. pusilla (Ill.)	-	1	1	-	-	-
Epuraea spp.	-	-	2	-	-	-
Soronia punctatissima (Ill.)	-	1	-	-	-	-
Byrrhidae						
Syncalypta striatopunctata Steff.	-	-	-	1	-	-
Rhizophagidae						
Rhizophagus parallelocollis Gyll.	-	-	12	1	-	-
R. perforatus Er.	-	-	4	-	-	-
Rhizophagus sp.	-	1	4	2	-	-
Cucujidae						
Silvanus sp.	-	1	-	-	-	-
Psammoecus bipunctatus (F.)	-	1	-	-	-	-
*Prostomis mandibularis F.	-	56	5	-	-	4
Cryptophagidae						
Cryptophagus c.f. dentatus (Hbst.)	-	1	1	-	-	1
Cryptophagus spp.	-	3	1	1	-	1
Atomaria mesomelaena (Hbst.)	-	1	-	-	-	-
Atomaria spp.	-	-	4	-	-	-
Lathridiidae						
Enicmus fungicola Thoms.(rugosus (Hbst.)	-	-	2	2	-	-
E. histrio Joy	-	-	-	1	-	-
Corticaria pubescens (Gyll.)	-	2	-	-	-	-

	1.	2.	3.	4.	5.	6.
Corticaria spp.	-	1	-	2	-	-
Corticarina gibbosa (Hbst.)	-	1	-	-	-	-
Corticarina spp.	-	1	-	5	-	-
Corticarina/Melanophthalma spp.	-	2	-	-	-	-
Corticaria/Corticarina/Melanophthalma spp.	-	-	6	-	-	-
Cartodere saparanda (Rtt.)	-	-	8	-	-	-
Mycetophagidae						
Litargus connexus (Geoff. in Fourc.)	-	2	-	-	-	-
Mycetophagus piceus (F.)	-	1	-	-	-	-
Colydiidae						
Colydium elongatum (F.)	-	-	1	-	-	1
Teredus cylindricus (Ol.)	-	9	7	3	-	-
Cerylon histeroides (F.)	-	-	2	-	-	-
C. prob. histeroides (F.)	-	-	3	-	-	-
Endomychidae						
*Mycetina cruciata Schall.	-	1	-	-	-	-
Coccinellidae						
Coccidula rufa (Hbst.)	-	1	-	-	-	-
Chilocorus renipustulatus (Scrib.)	-	1	-	-	-	-
Rhyzobius litura (F.)	-	-	-	1	-	-
Coccinella septempunctata L.	-	-	1	1	-	-
Aspidiphoridae						
Aspidiphorus orbiculatus (Gyll.)	-	2	-	-	-	-
Ciidae						
*Rhopalodontus baudueri Abeille	-	1	-	-	-	-
Ennearthron sp.	-	-	4	-	-	-
Cis micans (F.)	-	1	-	-	-	-
C. setiger Mel.	-	-	-	1	-	-
Cis spp.	-	3	-	1	-	-
Octotemnus glabriculus (Gyll.)	-	-	1	-	-	-
Anobiidae						
Grynobius planus F.	-	2	1	1	-	-
Xestobium rufovillosum (Deg.)	-	1	-	-	-	-
Gastrallus immarginatus Müll.	-	1	-	-	-	-
Anobium punctatum (Deg.)	-	1	3	-	-	1
A. fulvicorne Sturm.	-	1	-	-	-	-
A. denticolle Creut.	-	-	-	1	-	-
Dorcatoma chrysomelina sturm.	1	5	-	-	-	-

	1.	2.	3.	4.	5.	6.
Caenocara sp.	-	2	-	-	-	-
Ptinidae						
Ptinus fur (L.)	-	2	9	1	-	-
P. palliatus (Per.)	-	3	-	-	-	-
Salpingidae						
Rhinosimus planirostris (F.)	-	1	-	-	-	-
Xylophilidae						
Xylophila brevicornis (Perris.)	-	1	-	-	-	-
X. oculata Panz.(pygmaea Brit.auct.) /pygmaea Deg.	-	4	-	-	-	-
Mordellidae						
Anaspis sp.	-	-	1	-	-	-
Serropalpidae						
Hypulus quercinus (Quens.)	-	-	7	3	-	-
Orchesia (?) micans (Panz.)	-	-	1	-	-	-
O. undulata Kr.	-	1	-	-	-	-
Phloiotrya vaudoueri Mls.(rufipes Brit.Auct.)	-	-	1	-	-	-
Alleculidae						
Mycetochara humeralis (F.)	-	-	-	1	-	-
Prionychus melanarius(Germ.)(fairmairei Brit. auct.)	-	1	1	-	-	-
Tenebrionidae						
Hypophloeus unicolor (Pill.& Mitt.)	-	1	-	-	-	-
H. (?) bicolor (Ol.)	-	-	3	-	-	-
H. fraxini Kug.	-	4	-	-	-	-
Hypophloeus spp.	-	1	1	-	-	-
Scarabaeidae						
Geotrupes sp.	1	1	-	-	-	-
Aphodius luridus (F.)	-	1	-	-	-	-
A. sphacelatus (Panz.)	-	1	-	-	-	-
Aphodius spp.	1	-	4	1	-	-
Phyllopertha horticola (L.)	-	1	-	1	-	-
Cerambycidae						
Rhagium bifasciatum F.	-	1	1	-	-	-
Rhagium sp.	-	1	-	-	-	-
Grammoptera variegata (Germ.)	-	1	-	-	-	-
[illegible]ptura scutellata F.	-	1	-	-	-	-
Anaclyptus mysticus (L.)	-	-	-	-	-	2
Mesosa [illegible] (F.)	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
Chrysomelidae						
Plateumaris discolor (Panz.)	-	-	1	-	3	-
P. sericea (L.)	-	5	1	3	1	2
Plateumaris sp.	-	1	-	-	-	-
Phaedon versicolora (Laich.)	-	1	-	-	-	-
Chrysomela aenea L.	-	1	-	-	-	-
Phyllodecta vulgatissima (L.)	-	3	1	-	-	-
Lochmaea capreae (L.)	-	2	1	-	-	-
L. suturalis (Thom.)	-	-	-	2	-	-
Haltica (?) lythri Aubi.	-	1	-	-	-	-
Aphthona lutrescens (Gyll.)	-	-	1	1	-	-
A. cyanella (Redt.)	-	-	-	4	-	-
Chalcoides fulvicornis (F.)	-	1	-	-	-	-
Chalcoides sp.	-	-	1	-	-	-
Curculionidae						
Deporaus betulae (L.)	-	1	-	-	-	-
Apion minimum Hbst.	-	1	-	-	-	-
A. simile Kirby	-	1	-	-	-	-
Apion spp.	1	5	4	1	-	-
Otiorrhynchus sulcatus (F.)	-	-	-	1	-	-
Polydrusus cervinus (L.)	-	-	1	1	-	-
Sitona hispidulus (F.)	-	-	-	2	-	-
Dryophthorus corticalis (Payk.)	-	-	-	1	-	1
Eremotes ater (L.)	-	2	45	11	-	-
Bagous tempestivus (Hbst.)	-	-	-	1	1	-
Bagous sp.	-	-	-	-	1	-
Tanysphyrus lemnae (Payk.)	-	6	-	-	-	-
Notaris acridulus (L.)	-	2	-	-	-	-
Curculio villosus F.	-	-	1	-	-	-
C. pyrrhoceras Marsh.	1	1	-	-	-	-
C. salicivorus Payk.	-	-	1	-	-	-
Trachodes hispidus (L.)	-	1	-	-	-	-
Acalles roboris Curt.	-	1	3	-	-	-
A. ptinoides (Marsh.)	-	-	2	1	-	-
*Acalles sp.	-	-	-	1	-	-
Coeliodes rubricundus (Hbst.)	-	1	-	-	-	-
Ceuthorhynchus sp.	-	-	2	-	-	-
Ceuthorhynchinae indet.	-	4	-	-	-	-

	1.	2.	3.	4.	5.	6.
Rhynchaenus quercus (L.)	2	2	1	-	-	-
R. pilosus (F.)	1	1	-	-	-	-
R. avellanae (Don.)	-	1	-	-	-	-
R. rusci (Hbst.)	-	4	1	-	-	-
R. stigma Germ.	-	1	-	-	-	-
Rhynchaenus sp.	-	2	1	-	-	-
Rhamphus pulicarius (Hbst.)	-	3	-	-	-	-
Scolytidae						
Scolytus intricatus (Ratz.)	-	1	-	-	1	-
S. ratzeburgi Jans.	-	1	-	-	-	-
Myelophilus piniperda (L.)	-	1	-	-	-	-
Hylastes opacus Er.	-	1	-	-	-	-
Dryocoetes villosus Eich.	-	15	140	8	-	-
Pityophthorus (?) lichtensteini (Ratz.)	-	-	1	-	-	-
Pityogenes quadridens(Hart.)/bidentatus (Hbst.)	-	-	1	-	-	-
Xyloborus saxeseni (Ratz.)	-	3	1	-	-	1
Platypodidae						
Platypus cylindrus (F.)	-	3	1	1	-	-
Hymenoptera						
Xiphydriidae						
Xiphydria prolongata (Geoff. in Fourc.)	-	1	-	-	-	-
X. camelus (L.)	-	1	-	-	-	-
Parasitica						
indet.	not counted					
Formicidae						
Myrmica spp.	-	-	-	1	11	-
Lasius fuliginosus (Lat.)	-	-	-	2	-	-
L. niger (L.)	-	9	-	-	-	1
Lasius spp.	-	-	-	-	7	-
Diptera						
Bibionidae						
Dilophus sp.	-	-	-	1	-	-
Tipulidae						
indet.	not counted					
Puparia indet.	not counted					

Water was added and the insect-rich flotant washed and sorted in alcohol. The sample from the base of the Sphagnum peat, however, (Sample 5), was difficult to break down, the Sphagnum being held together by an interwoven mass of rhizomes, subsequently identified as cranberry, Vaccinium oxycoccus. Paraffin treatment only caused virtually the entire sample to float and no better separation could be achieved by use of sodium carbonate solution or by boiling the sample. Eventually the whole 10 kg. had to be sorted beneath the binocular microscope; this sample produced far fewer insects than the brushwood and fen peat samples.

Environmental Interpretation

Although a sample was washed out from the silts beneath Sample 1, it contained very little organic material and no insect remains or recognisable plant macrofossils, other than rootlets. Pollen preparations, however, from 5, 15 and 25 cm. into the deposit did produce occasional grains and spores. In the lowest sample, forty-seven traverses of the slide produced a total of thirteen grains and in the second five grains were noted in thirty-three traverses; the sample closest to the gradational interface with the peat, which, by its darker colour, clearly included more organic material, produced about one hundred and fifty grains in forty traverses, although only twenty are of tree genera (Table 9).

The occurrence of juniper pollen in these samples is enigmatic. Despite the repeated examination of samples from several localities, no identifiable organic remains have yet been recovered from the laminated silts of pro-glacial Lake Humber (Gaunt, pers.comm.), to which, tentatively and with some circularity of argument, these

Table 9

Thorne Moors: Trackway Site - Pollen and spores

from sediments beneath peat and from basal peat sample

	Silts		Peat	
	1 (-25 cm)	2 (-15 cm)	3 (-5 cm)	4 (+5 cm)
A.P.				
Betula	-	-	2	7
Pinus	-	-	4	1
Quercus	-	-	-	37
Tilia	-	-	3	-
Alnus	-	-	8	100
Juniperus	1	1	3	-
Corylus	-	-	8	51
N.A.P.				
Gramineae	9	3	70	45
Cerealia	-	-	-	40
Cyperaceae	1	-	1	3
Ericaceae	-	-	-	-
Compositae	-	-	1	-
Thalictrum	-	-	1	-
Sphagnum	2	1	3	-
Filicales	-	-	10	2
Polypodium	-	-	24	10
Hystrix	-	-	3	-

(for location of samples, see fig. 66)

silts have been related (above p.172). They would appear, however, to represent the terminal phase of the lake and the pollen may have been incorporated during deposition, possibly during zone I, when Bartley's (1962) diagram from near Tadcaster, c.35km. to the north-west, shows a rise in frequency of juniper to 44% of the total pollen in one sample. Incorporation after the deposition of the silts by invertebrate action is possible and this explains the apparently mixed spectrum from pollen Sample 3, but the Tadcaster diagram (op. cit.) does not show a return to high juniper frequencies late in zone III and into zone IV, although such is a common feature of many British diagrams (Godwin, 1975), and it is absent from all diagrams of later date from the Vale of York (Smith, 1958; Turner, unpubl., above p.141). In the south Pennines, Tallis (1964) has demonstrated that this shrub was extinguished by the expansion of blanket bog from zone VII(a) onwards but it remains native elsewhere in the Highland Zone and on some calcareous soils, notably on the Chalk in south-east England, where it occasionally appears in late pollen diagrms (e.g. Bradley & Keith-Lucas, 1975). An origin for the Thorne pollen penecontemporaneous with the inception of peat growth towards the end of zone VII(b) would therefore seem improbable, particularly since this would also require either differential preservation, which the state of the grains does not support, or selective resorting by invertebrate action, a process which Dimbleby's (e.g. 1962) work on soil pollen would imply does not occur. The survival of sparse grains of Late Devensian age in the sediment is the most acceptable explanation. More detailed, closer sampling and substantial absolute counts from the silts would be necessary to examine the sequence of Late Glacial pollen preservation followed by a diastema of several thousand years before the deposition of pollen in the mixed Sample 3, but it is apparent that the active

layer of the Flandrian soil had been shallow throughout its existence, despite the much lower water-table during most of this period, acidity perhaps inhibiting arthropod and worm sorting and preserving the pollen. Survival of pollen towards the base of the former active layer could have been the result of waterlogging but the absence of hazel and presence of lime amongst the few grains of arboral pollen from the uppermost silt sample suggests a gap between this and the first peat sample, 10 cm. above. If anything can be deduced from the Sample 3 spectrum, the large number of grains of grass pollen would imply a Neolithic or later date, after some clearance, and the apparent break in the sequence may be covered by the soil pollen within the remaining 5 cm. of slightly humic silt, preserved by the incipient podsolization of the profile.

At the level of pollen Sample 4, the gradation from silt stained by humic compounds to a virtually wholly organic peat had progressed to a stage where organic material and amorphous humifaction products had largely replaced silt, the horizon approaching a 'moder humus' inhibited by progressive waterlogging. A bulk sample, taken to 5 cm. either side of the pollen sample, produced a sufficient insect fauna for comparison with the palynological data, although preservation was fitful, with only forty-six identifiable individuals (1 in Table 9). The pollen spectrum is unusual for its high percentage of cereal pollen, reaching 14% of the total pollen (n=284) and, with the Gramineae, amounting to nearly 30%; these high totals are unaccompanied by ruderals (Table 9). The tree pollen sum, including Corylus, is also high at 69% of total, implying fairly closed woodland. Seeds of alder were common in the sample washed out for insect remains and four individuals of oak leaf mining weevils, Curculio pyrrhoceras,

Rhynchaenus quercus and R. pilosus, were also recovered, suggesting the immediate proximity of both oak and alder, perhaps biasing the pollen count. Abstracting the alder pollen as local overweighting, reduces the tree pollen to 52% of the sum, still well above the 40% usually accepted as indicating a partially cleared landscape (Pennington, 1969). Omission of hazel, a tree regarded as an under-shrub and not counted within the arboral total in may diagrams (Godwin, 1975), further reduces this total to 34%, within the partially cleared landscape figure, but the number of actual grains involved is too small for much significance to be attached to it. It should be noted, however, that hazel does not flower readily under closed canopy conditions and the relatively high count of 26% total tree pollen, including Corylus, is itself indicative of some opening up of the forest.

The limited insect fauna gives no definite indication of open ground and the majority of taxa are either eurytopic or associated with woodland or timber. Although Bembidion doris tends to be very hygrophilous (Lindroth, 1974) and Corylophus cassidoides a species of Phragmites litter, true water beetles are entirely absent from the assemblage at this level and there are no indications of the open water and detritus-rich ponds which appear higher in the succession. Much of the fauna would not be out of place in an assemblage recovered by pit-fall trapping in woodland, as those of Evans (1969) from Cheshire woods. The one Elaterid, Agriotes pallidulus, is a common species of mixed deciduous woodland (Horion, 1953; Evans, 1969). In addition to the oak leaf mining weevils, moribund or dead timber is implied by [illegible]sis buprestoides, whose larvae develop in several species of deciduous tree, especially beech and hornbeam (Palm, 1959), neither of which occur in the pollen diagram, although it is also known from oak (Donisthorpe, 1939). Dorcatoma chrysomeloides also occurs in wood,

particularly oak, attacked by fungi. The two dung beetles, Geotrupes sp. and Aphodius sp., may suggest herbivores in the vicinity but both are active fliers and could be adventitious. The assemblage could relate to a single oak, with its litter, in a forested environment and the pollen record of polypody (Polypodium vulgare) is also consistent with this interpretation.

The amount of available data upon modern insect life and death assemblages is still pitifully small and papers such as those of Evans (1969(a)&(b). and Kenward (1975) form a slim volume in the entomological literature. The Thorne faunal list is too limited for interpretation of much more than the immediate local environment and only the most exhaustive of faunal lists would contain enough adventitous species to hint at the nature of other, different, adjacent habitats. The character of the less immediate area is therefore only available via the pollen data. Assuming that the forty grains of cereal pollen do not reflect a single anther, and the equally high count of grasses suggests not, some form of arable farming is clearly implied but its distance from the site of the spectrum is not to be easily ascertained. Smith's (1958) diagram from towards the southern edge of Hatfield Moors, 10 km. south of the Thorne site, shows a peak of nearly 10% of total tree pollen in the cereal curve early in zone VIII, but this sample is from a Sphagnum bog and transport on a more regional basis, perhaps from crops on the sands and gravel island on which the present village of Wroot lies to the south, is probable. This cereal peak is also accompanied by high values for Plantago lanceolata, grasses and ruderals. Since the Thorne spectrum comes from the forest floor, the high percentage of grass and cereal pollen ought to have a very local origin, as movement through the closed environment would be minimal. The insect fauna precludes clearance at the sampling site and

it is tempting to relate the non-arboreal component to one of the two limited areas wherein the tree trunks at the base of the peat had charred surfaces (above p.163), which lay c.400m. to the north-east of the sampling site, and to suggest that both relate to an episode of small temporary clearances within the forest, fossilised by the rising water table. It might be countered that, by the time that plant and insect remains were able to be preserved, the soil would have become too waterlogged to bear a crop. Yet, the process of inundation by small winter increments to the subterranean water table could leave the soil away from the tree cover dry enough in the summer months, or perhaps for several seasons, to obtain a snatch crop or two of cereals. The somewhat moribund trees, injured by the rising water level, may themselves have been attractive to prospective cultivators as areas more easily cleared, although clearance itself would have exacerbated the problem (below p.220). The cut-off in grass and cereal pollen above this horizon is drastic and, as flooding advanced, birch expanded at the expense of oak (fig.66) although, in part, this rise may result from the recolonisation of formerly cleared areas. Certainly by the level of the next insect fauna, the change in the environment over to fen with open water would have wholly curtailed any farming activity on the area later occupied by Thorne Moors.

The Trackway Horizon (Insect sample 2 : pollen sample 6)

That the drastic decline in oak pollen at the trackway level, from over 25% of the tree pollen, excluding hazel, to just over 2%, results from progressively wetter conditions rather than direct anthropogenic interference is supported by the insect evidence. From a few individuals of varying preservation in sample 1, the insect fauna rises to more than eight hundred and fifty individuals in sample 2,

from between the timbers of the trackway, and of these, nearly one fifth are water beetles. The presence of several species characteristic of open water habitats, particularly the larger Dytiscids, Agabus spp., Ilybius spp. and Colymbetes fuscus, implies a reasonably sized pond and similar conditions, if less pronounced, occur around the base of the moribund oak from which sample 3 was recovered, c. 400 m. away. The majority of the Dytiscids and Hydrophilids in sample 2 belong to what Balfour-Browne (1940; 1950; 1958) has termed the detritus pond community and several, including Hydroporus dorsalis and H. memnonius are noted from woodland ponds with dead leaves (Balfour-Browne, 1940). H. scalesianus has been recorded in its few English localities from thick moss with clear water in fen swamps (op. cit.) but Guignot (1933) says that it prefers woodland pools in France and Girling's (1976) fossil records from throughout the Somerset Levels succession suggests that it may be even more eurytopic; in Norfolk it has been found in the same habitat as Ilybius guttiger, also in the Thorne list. A number of species imply some variation in the character of the open water: Agabus unguicularis, represented by up to nineteen individuals in the trackway, occurs in pools and acid water with Sphagnum, usually among the moss at the edges of pools (Balfour-Browne, 1950) and A. paludosus prefers shallow streams with thick vegetation, although the solitary individual may be adventitious and Guignot (op. cit.) also notes it from stagnant water. Anacaena globulus is equally common in still and moving water but also occurs in the litter layer on the forest floor (Evans, 1969) and a gradation between the two environments is to be envisaged. Thick vegetation around the pond is suggested by Hydrobius fuscipes and Enochrus coarctatus but this element can give no indication of the plants involved. Open water is also required for the duckweeds, Lemna spp., on which the small weevil Tanysphyrus lemnae depends. Around the ponds and over the timbers, which formed the trackway, considerable moss growth is indicated

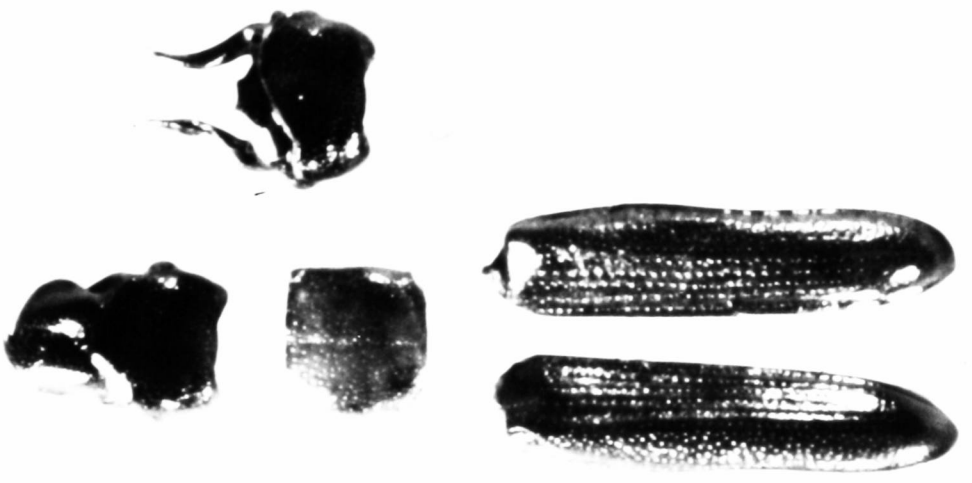

Figure 64. <u>Prostomis mandibularis</u> from Thorne Moors, showing characteristic processes beneath mandibles

Figure 65. Elytra of <u>Isorhipis melasoides</u> from Thorne Moors

by over two hundred Helodids, Crelostoma orbiculare and several Staphylinids, which commonly live as predators in wet moss. Spores of Sphagnum first enter the pollen diagram at this level and rapidly increase as raised bog takes over from the fen environment (fig. 66). Grasses and sedges are indicated by Plateumaris sericea and Notaris acridulus, whilst Psammoecus bipunctatus is frequently associated with Carex paniculata (Skidmore, pers. commun.). Haltica lythri occurs on Lythrum salicaria, purple loosestrife, a common flower of marshes and river banks. Sample 3, from a roughly contemporary horizon, adds Aphthona lutescens, which is recorded from Epilobium spp. in wet places (Mohr, 1966), Brachypterus urticae on nettles, and the bug Sehirus biguttatus on Melampyrum spp., usually the common cow-wheat, M. pratense. Caenocara spp. occur in Lycoperdon spp., the puff-ball fungi, which usually grow on drier sandy soils, although L. pyriforme occurs on tree stumps, which would fit this species into the rotten wood community of the trackway.

The palynological data from the trackway level would suggest a co-dominance of birch and alder (fig. 66), with subsidiary amounts of hazel, although the latter component might include some Myrica pollen. Pine and oak appear in sufficient quantity to suggest their presence in the region and elm and lime are represented by single grains. The insect data are more specific in terms of the immediate environment. The macroscopic evidence of a small pine incorporated in the trackway is supplemented by two bark beetles, Myelophilus piniperda and Hylastes opacus which, although recorded from other conifers (Chrystal, 1937), would, during most of the Flandrian, be restricted to pine as the only suitable native species. Pinus sylvestris is characteristic of the transition phase between fen and raised bog (Godwin, 1975) and its utilisation in the construction of the track need not have involved its portage over any distance. The large numbers of species associated

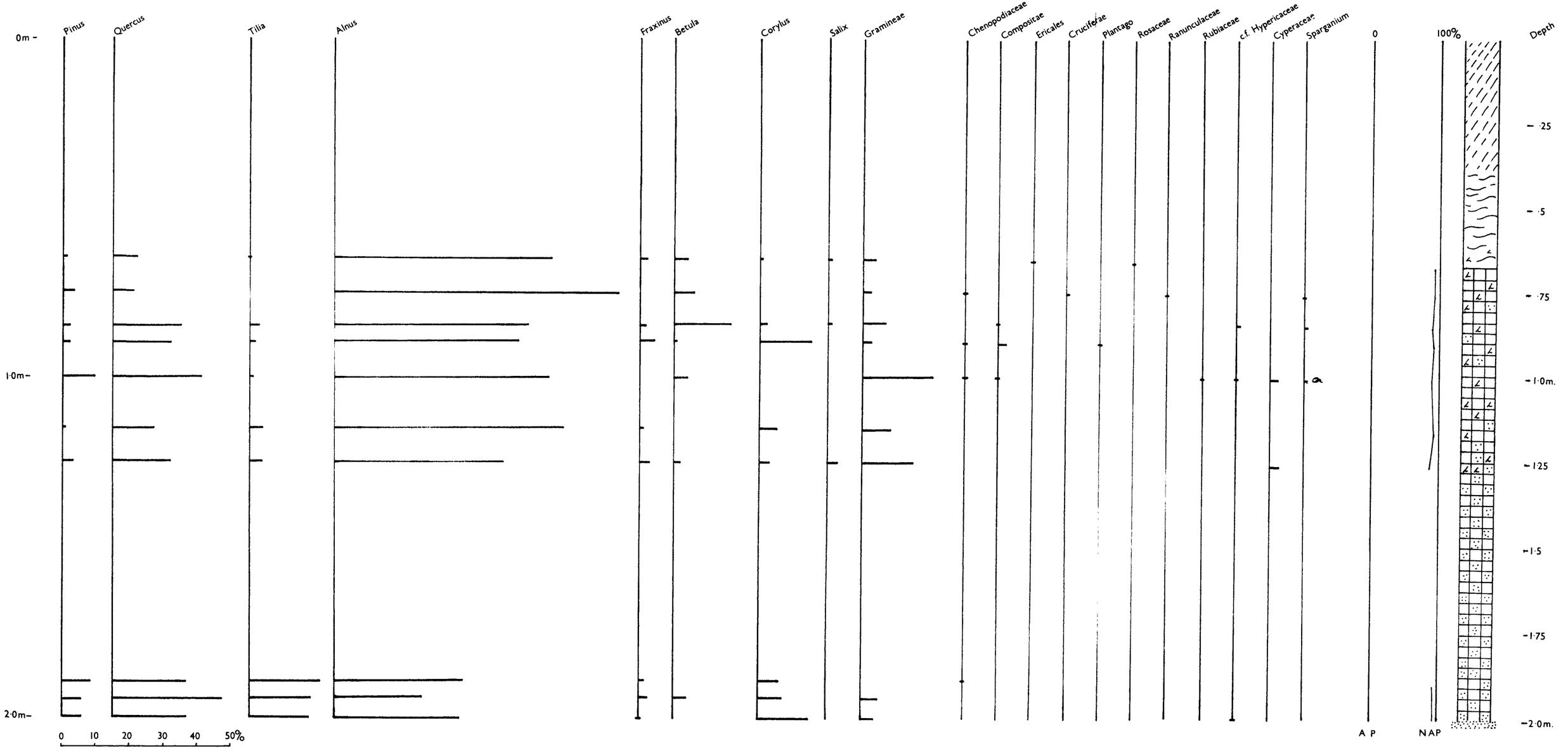

Figure 51. Misterton Carr : Pollen Diagram

Table 10

Thorne Moors: Plants indicated by the Insect Record

Taxa		Host
Myelophilus piniperda	(2)	Pinus silvestris
Hylastes opacus	(2)	" "
Apion simile	(2)	Betula alba
Coeliodes rubicundus	(2)	" " (rarely Fraxinus)
Rhynchaenus rusci	(2,3)	" " & Populus nigra
Deporaus betulae	(2)	" " & B. pubescens (rarely Alnus, Corylus, etc.)
Scolytus ratzburgi	(2)	Betula spp.
Xiphydria camelus	(2)	" " & Alnus glutinosa
Curculio villosus	(3)	Quercus spp.
C. pyrrhoceras	(1,3)	" "
Rhynchaenus avellanae	(2)	" "
R. quercus	(1,2,3)	" "
R. pilosus	(1,3)	" "
Acalles roboris	(2,3)	usually Quercus spp.
Chrysomela aenea	(2)	Alnus glutinosa
Curculio salicivorus	(2,3)	Salix vitellina
Chalcoides fulvicornis	(2)	S. caprea, S. atrocinerea, etc.
Plagiodera versicolora	(2)	Salix spp., often S. fragilis, (rarely Populus spp.)
Phyllodecta vulgatissima	(2,3)	Salix spp.
Apion minimum	(2)	" "
Raphidia notata	(2)	" "
Lochmaea capreae	(2,3)	" " , Populus spp. & Betula
Chalcoides sp.	(3)	" " " "
Rhynchaenus stigma	(2)	Salicaceae & Betulaceae

Table 10 (Cont.)

Thorne Moors: Plants indicated by the Insect Record

Xiphydria prolongata	(2)	Salix spp. also Populus & Alnus
Aphthona hispidulus	(4)	various Cruciferae
Aphthona lutescens	(3,4)	Epilobium spp. in wet places
Haltica lythri	(2)	Lythrum salicaria
Lochmaea suturalis	(4)	Calluna vulgaris
Acalles ptinoides	(3,4)	" " (but also from standing deciduous trees)
Sehirus biguttatus	(3)	Melampyrum pratense (prob. spp.)
Aphthona cyanella	(4)	Euphorbia spp.
Brachypterus urticae	(3)	Urtica spp.
Tanysphyrus lemnae	(2)	Lemna spp.
Bagous tempestivus	(4,5)	Potomogeton spp. P.(Groenlandia) densus, P. pectinatus, etc.
Plateumaris discolor	(3,5)	Carex spp.
P. sericea	(2,3,4,5)	" " & Iris pseudocoris
Notaris acridulus	(2)	Cyperaceae. adults on Glyceria spp. & Polygonum amphibium
Polydrusus cervinus	(3,4)	imagines polyphagous, larvae on roots of Dactylis glomerata

Fungi:

Caenocara sp.	(2)	Hycorerdon spp.
Cis micans	(2)	Trametes versicolor (prob. spp.)
C. setiger	(4)	Trametes spp.
Octotemnus glabriculus	(3)	" "

with birch, including Apion simile, Coeliodes rubicundus, Rhynchaenus rusci, Deporaus betulae and Scolytus ratzburgi (table 10), support the pollen evidence for the presence of this tree around the trackway site and its macrofossils were frequent in the peat. The slightly firmer ground provided by the timbers provided a base upon which a tree birch managed to establish itself after the trackway had fallen into disuse. Whether the indications of the entomological literature (Hoffman, 1954) that the larvae of A. simile, C. rubicundus and R. rusci are to be found upon the leaves of Betula pendula rather than B. pubescens, more typical of fen (Godwin, 1975) reflect an actual situation or insufficient data cannot be resolved; most British entomologists (e.g. Donisthorpe, 1939) merely refer to the collection of adults by sweeping with a net about oaks, willows and birch. Since there are fewer taxa of Coleoptera which are specific to alder, the evidence for this tree in the insect list is less substantial. Chrysomela aenea appears to be restricted to Alnus (Mohr, 1966) and Deporaus betulae may occasionally be found upon it (Hoffman, 1954), sufficient, with the pollen data to substantiate the picture of a birch-alder fen.

It is unfortunate that the insect evidence goes no way towards resolving the problem of the Coryloid component in the pollen diagram. No feeders upon either hazel or bog myrtle were found and, whilst in the forest floor spectrum Corylus is the more probable, with the development of a more acid fen environment above the trackway, Myrica pollen may become a significant contributor to the Coryloid curve. Smith (1958) does not split the two elements in his Hatfield Moors diagram and Turner (1962) regards the variation in this curve in her Thorne Moors diagram as due to changes in the status of hazel. It should be noted, however, that, when Leland crossed the Chase to Haxey in the 1530's, he remarked upon the preponderance of sweet gale on the peatlands. One major element of the fen flora not represented in the pollen spectrum and

consistently under-represented in counts is the willow. Curculio salicivorus, Chalcoides fulvicornis, Plagiodera versicolora, Phyllodecta vulgatissima and Apion minimum all feed upon the leaves of various species of Salix (table 10). Hoffman (1954) records C. salicivorus from the galls of several species of Tenthredid sawfly on the leaves of white willow, S. alba, and Mohr (1966) notes a preference of P. versicolora for the crack willow, S. fragilis; the sallows are preferred by C. fulvicornis (Allen, 1972). The ladybird Chilocorus renipustulatus preys on scale bugs (Coccidae), usually Chionaspis salicis on willows but in Scandinavia it is also recorded, intermittently, from aspen, ash, alder (Palm, 1959) and conifers (Kopenen & Nuorteva, 1973). The image must therefore be modified to accommodate a gradation from birch-alder fen, through willow swamp to some open water in the vicinity of the trackway.

The few grains of oak pollen need not imply the presence of this tree close to the sampling locality but the evidence of the phytophagous beetles is sufficiently strong to show that oaks existed close to the track and are under-represented in the pollen spectrum. Rhynchaenus avellanae and R. quercus attack the foliage of oaks and, although the imagines may move away from the host - Donisthorpe (1939) records R. quercus from flowers of crab-apple and hawthorn as well as oak - the larvae develop on oak leaves. The trackway evidence for the survival of oaks into the open water phase is expanded by the beetles from the basal sample from between the vanes of an oak stump (sample 3). As well as R. quercus, R. pilosus occurs, with Curculio pyrrhoceras and C. villosus, whose larvae inhabit the galls of the Cynipid wasps Dryophanta folii and Biorrhiza pallida respectively on oak leaves (Hoffman, 1954). Quercus is intolerant of flooding (Longman & Coutts, 1974) and the rising water table would have resulted in large numbers of moribund trees more susceptible to insect attack. Acalles roboris

would have attacked the thinner shoots of the trees as they died back and a whole range of lignicolous species the more substantial timber. Certainly pollen production would have been drastically curtailed and the oak, or indeed, any other similarly affected tree would be poorly represented in the spectrum. The death and decay of one large oak is documented by the changes in the fauna between samples 3 and 4 and the bark beetles, principally Dryocoetes villosus, decline from one hundred and forty individuals to eight; the leaf feeders do not reappear in the upper sample.

Into this environment of birch-alder fen with willow swamp and occasional pools, interspersed with numerous dead and moribund large trees, the remains of which were frequent at the base of the peat, the irregular structure of the Middle Bronze Age trackway has to be fitted. Although the reconstruction of the natural habitat is partially governed by the insecure parameters of people's collecting experience and published records, the trackway poses additional problems beyond its own immediate environment. The structure represents a conscious or unconscious selection of timber by man and cannot therefore be regarded as an unbiased sample of the local woodland. Although there is some suggestion of rough working on some of the timbers (above p. 168), it is apparent from the large and diverse xylophagous insect fauna that preference was shown for the more easily obtained dead and partially rotted trees, which were thrown into the mire, here probably a fairly open, if vegetated pool, to form an irregular surface. The accumulation of vegetable litter, small twigs, leaves and moss upon and in this surface was considerable and several taxa can be associated with this habitat, including Megasternum obscurum, Proteinus spp. and Oxytelus spp. Donisthorpe (1939) notes Cercyon convexiusculus, in numbers, from under a log in water and in moss in willow swamp at Windsor and such a habitat preference would

explain its dominance over the more eurytopic M. obscurum in the trackway sample; the roles are reversed in sample 3, from the base of the oak. This component of the fauna could equally well occur in dung but the few Scarabaeids, Geotrupes sp., Aphodius luridus and A. sphacelatus do not differ significantly in numbers from the other samples and only suggest the occurrence of herbivores within the general area. The irregular surface of the track, as preserved, may be misleading since the actual walking surface could have been composed of turf sods laid over the timbers. Usage would have reduced this to a composition indistinguishable from the remainer of the peat and it would form a habitat suitable for much of the omnivorous and carnivorous elements in the fauna. There is no evidence of the use of reeds to provide a surface, as practised until recent times in the Fens (Porter, 1969). Fragments of Phragmites communis were noted in the peat over the trackway but the true reed forms part of the natural seral succession from open water to wooded fen and, in the limited amount of excavation carried out, there was no evidence for the concentration of these over the timbers. Equally, the employment of twigs, litter and moss over the wood would not have been recognisable by unusual features of the fauna.

The dead wood element in the trackway faunal assemblage is considerable. Over thirty-five species are actual borers in timber in various stages of decay and many more live as predators or commensals in the burrows or under the bark. Several taxa would appear, on the evidence from Britain, to be tied to a particular species of tree but, frequently, Continental sources reveal a much wider range of hosts. In table 10, therefore, only those species of lignicolous insect have been included which have only one possible native host in Britain, as those recorded only from conifers, or about which British and Continental sources, principally Escherich (1923), Horion (1941 et seq.) and

Palm (1951; 1959) are unanimous about the host trees. Thus, the wood-boring weevil Eremotes ater is only recorded from pine in Britain yet, on the Continent, it is quite catholic in its tastes, taking a whole range of deciduous woods, as well as conifers (Palm, 1959; below p.261). Gastrallus immarginatus occurs in maple in its solitary British haunt, Windsor (Allen, 1956), but is recorded from a considerable range of deciduous woods in Europe (Kaszab, 1969). Duffy (1953) has pointed out that it is not usually the species of timber which is important but the state of the wood, its temperature, humidity, state of decay, etc., and, whilst this is least true of the Scolytids, the more primary of the agents, it becomes progressively more evident through the ecological succession which results in decay and incorporation of the timber in the soil. As Palm's work for the Swedish forestry service has shown (1951; 1959), very few insects are primary pests of living, healthy trees and many require some degree of fungal intervention before they can ingest the intractable cellulose of the wood. Death watch, Xestobium rufovillosum, also present in the trackway fauna, in synanthropic situations is a secondary pest after wet or dry rot (Fisher, 1938) and many other species are associated with already rotted wood, feeding on both the broken down timber and the fungal hyphae. Mycetina cruciata, Aspidiphorus orbiculatus, Dorcatoma chrysomeloides and Ptinus fur belong to this community, although it has to be remembered that several may occur in many situations where mould and other fungi are to be found. Rhysodes sulcatus and Prostomis mandibularis also occur in thoroughly rotten wood. The Ciids and several of the Staphylinids are found in the fungal fruiting bodies of bracket and other fungi on trees, the latter largely as predators on fungus gnat larvae. A number of other predators live under bark; the Histerids, Abraeus globosus and Micrologmalus parallelipipedus, preying on dipterous larvae or Scolytids

(Horion, 1949) and Baptolinus affinis, Trinodes hirtus and Rhinosimus planirostris living either as predators or as scavengers in this habitat. The two Rhizophagids are probably to be classed as predatory, although there is some doubt as to whether Rhizophagus parallelocollis is not a fungal feeder (below p.241). Several of the other carnivorous species would exploit the cover provided by the loose bark, decayed wood and thick moss growth on the trees, the latter a feature which pollution has removed from most modern woods. Crowson (1962) notes that Agonum obscurum is particularly common in moss on trunks in Scottish oakwoods and several species utilise both moss, thoroughly rotted wood and under bark as hibernation sites.

The succession of lignicolous beetles as they contribute to the decay of a tree is well illustrated by samples 3 and 4, from between the buttresses of a large oak stump still in the position of growth (fig. 63). In the moribund state of a tree, the leaf feeders are supplemented by the Scolytids, Dryocoetes villosus and Xyloborus saxeseni, with Platypus cylindrus and, as fungi attack the wood and the bark is loosened, wood-boring species enter, principally the weevil Eremotes ater but also the longhorn Rhagium bifasciatum, the furniture beetle Anobium punctatum, Grynobius planus, Teredus cylindricus, Hypulus quercinus and several Elaterids. The loosened bark and accumulating frass provide habitat for both fungivores and predators and, as the wood begins to split along its annual rings, Prostomis mandibularis moves in. In sample 4, as the timber begins to lose its cohesion and character and frass comes to dominate over wood, the Scolytids and some of the wood-borers decline and are replaced by species which rework this material, Rhysodes sulcatus and Dryophthorus corticalis. The ecological progression which would have finally returned the wood to the soil has been curtailed by peat formation, which precluded all organic activity until

the stump was exhumed during drainage. The upper sample shows a considerable decline both in diversity and number of individuals, heralding the transition from fen to raised bog.

The raised bog (Insect sample 5 : pollen sample 8)

The invasion of Sphagnum into the fen and willow swamp is evident not only from the rapid rise in the number of spores in the pollen diagram (fig. 66) but also from the changing character of the peat itself. In the 15 cm. between the trackway horizon and sample 5, all wood, other than occasional small birches and some twigs, probably of Calluna, disappears and the deposits assume the aspect of a uniform moss peat with little variation, other than in degree of humifaction. At the horizon selected for insect sample 5, the rather humified Sphagnum was knitted together by an intertwined mass of rhizomes of Vaccinum oxycoccus and several birch trunks appear at a similar level elsewhere along the sections, from one of which the complete example of a male imago of the large Ostomid Ziomoma grossum was recovered (fig.fro.). Although the whole of this part of the succession must lie early in pollen zone VIII and within a few hundred years of the 2980 ± 110 B.P. (Birm. 358) from the trackway, the irregular nature of the surface of raised bogs and variation in degree of wetness makes it impossible to assume that the age of the specimen of Z. grossum is exactly that of the radiocarbon date.

The transition towards more acid conditions is also evident from several changes within sample 4. Although the dead stump of the oak still projected above the surface of the bog, its environment had changed considerably. All the feeders upon living trees disappear and there are no indicators of birch or willow scrub. The phytophages are restricted to dead wood species and a few feeders upon lower plants:

Aphthona lutescens on the willow herbs, Epilobium spp. in wet areas, A. cyanella on the spurges, Euphorbia spp. and Sitona hispidulus on various species of Cruciferae. None of these are suggestive of raised bog but the heather beetle, Lochmaea suturalis, usually occurs on ling, Calluna vulgaris, and the weevil Acalles ptinoides bores into the thicker twigs of this plant, although, on the Continent, it is also recorded from deciduous trees away from heath (Palm, 1959), which would account for its appearance in the underlying sample. Several changes occur within the Carabid fauna which also indicate an opening up of the habitat. Both Bradycellus ruficollis and B. harpalinus often occur on the ground beneath Calluna (Lindroth, 1974) and this pair are the most frequent predatory taxa in sample 4, largely replacing the species of Feronia which favour wetter situations. The predominantly woodland Trechus secalis is replaced by the more xerophilous T. quadristriatus/obtusus, although it should be noted that Lindroth (1945) notes the former from under Calluna in Denmark. Similarly the deciduous woodland and fen species Trichocellus placidus gives way to the dry heath T. cognatus, which is also recorded from raised bogs in southern Sweden (op. cit.). A change also occurs in the predatory Lygaeid bugs, from the shade-favouring Drymus brunneus to the more xerophilous D. syvaticus/ryei (Southwood & Leston, 1959).

Some relatively permanent open water is implied by Bagous tempestivus, which is found on various species of pondweed, Potomogeton spp. Its more frequent hosts, P. (Groenlandia) densus and P. pectinatus (Hoffman, 1954), are more characteristic of eutrophic rather than oligotrophic waters but, since this weevil also appears in the acid bog environment of sample 5, it may be more eurytopic than this French record suggests. The water beetles in sample 4 also include some fen indicators, perhaps a consequence of the arbitrary nature of the division between samples 3 and 4. Both Hydroporus

neglectus and H. memnonius occur in forest pools (Guignot, 1933; Zimmerman, 1931) on the Continent and Enochrus coarctatus, although a detritus pond insect, is not usually found in acid water (Balfour-Browne, 1958). Agabus congener, on the other hand, is largely an upland species of Sphagnum pools, with occasional lowland captures, including the New Forest and possibly Askham Bog, near York (Balfour-Browne, 1950). This admixture of differing ecotypes may merely reflect differing stages in the hydroseral succession across the few kilometres of enascent raised bog and meandering river courses, flanked by willow swamp and fen. Being efficient fliers, it is not surprising that these water beetles sometimes appear away from their usual habitat.

Sample 5 continues the progression into raised bog. The number of insects declines drastically and only one individual associated with rotten wood occurs, Dolopius marginatus, a species very catholic in its selection of wood, the larvae also appearing as predators in woodland soils (Horion, 1953) and the imago being an active flier. The evidence from other sources, particularly the stratigraphic, is sufficiently strong to preclude the proximity of fresh oak, the principal host of the bark beetle Scolytus intricatus, to the site. The insect is also recorded from beech, hornbeam, elm and hazel and seems less fastidious than most Scolytids in its selection of the state of the host tree (Palm, 1959). As the recent rapid spread of Dutch elm disease has emphasised, members of this genus are usually efficient fliers and the individual is probably adventitious.

Although the occurrence of some open water is suggested by the foodplants of Bagous tempestivus, the pondweeds, there are only two water beetles in sample 5, both Hydroporus spp., and the changes in the peat stratigraphy across the sampling horizon, from humified to much less humified Sphagnum peat with leaves and rhizomes of Scheuchzeria palustris, a plant which survived on the Moors in its last lowland

station until the 1940's (Bunting, pers. comm.), shows that this level marks a recurrence surface in the raised bog. It is tempting to relate this particularly marked phase of drying followed by swamping to Granlund's RYIII, Weber's original Grenz, of c. 600 B.C., the most extensive of the north European Grenzhorizont but recent work, particularly that of Schneekloth (1968) on German bogs, urges caution (Moore & Bellamy, 1973). Much more extensive sampling of both macroplant and insect remains, as well as ^{14}C dates, over this surface would be necessary to provide useful comment upon recurrence surfaces. Apart from the almost total disappearance of woodland and aquatic elements and the depleted nature of the fauna, many of the more eurytopic of the wet moss community recur in sample 5; large numbers of Helodids remain, more individuals of Coelostoma orbiculare occur and the few Staphylinids are supplemented by Erichsonius cinerescens. The paucity of the faunal assemblage reflects the depauperate character of raised bogs when compared with fen woodland.

The rise in the oak pollen curve between the trackway and the level of the upper insect sample, at the expense of birch and alder with a continued decline in the Coryloid component (fig. 66), may reflect the natural succession in the hydrosere, with the expansion of oak into the drier parts of the fen elsewhere on the Chase but it is apparent from the higher samples and the insect evidence that a much wider, regional component is entering into the pollen rain. Carpinus is represented by a single grain in pollen sample 7 and it is doubtful whether the hornbeam is a native tree outside south-east England (Godwin, 1975), suggesting long distance transport. Fagus presents more of a problem. Although macroscopic records are restricted to south of the Wash (op. cit.), the tree has a low, intermittent, pollen production of low dispersal potential and it is possible that small stands existed as far north as the Lake District by the end of zone VII.

Despite the appearance of such insects as Eucnemis capucina, which in this country show a preference for rotting beechwood (below p.240), there is no conclusive evidence for the tree's presence on the Levels, where the predominantly sandy soils are not suitable without husbanding and the pollen probably represents local stands on the Magnesian Limestone dipslope, c. 20 km. to the west. The varying amounts of elm and lime pollen presumably also reflect changes further west and Turner (1962) suggests that the variations within her Tilia curve record selective clearance events on the limestones, although there is some evidence for the continuance of lime on the Chase (below p.285). The single grain of Euonymus europaeus, the spindle tree, is only the second published record (Godwin, 1975); this shrub today is frequent, if localised, on the Magnesian Limestone.

The fall in frequency of tree pollen in the top 40cm. of the Sphagnum peat (table 11) probably reflects the extensive clearances of the Iron Age and Roman periods, postulated on palynological grounds by both Smith (1958) and Turner (1965) and confirmed by recent aerial survey work over Hatfield Chase and the Permo-Triassic outcrops (below p.303 & fig. 86; Riley, 1973). Pollen of the grasses rises considerably and cereals again appear in the spectrum, together with Artemisia, Plantago, Rumex, Urtica and the Chenopodiaceae, probably reflecting agricultural activity on the slightly higher sandy areas between Thorne and Hatfield Moors. The increase in Ericaceae at the top of the column, immediately below the latest peat cutting surface, with the accompanying rise in Gramineae, may correlate with a similar event on Hatfield Moors noted by Smith (1958) and occurring within the Romano-British period but a considerably more detailed diagram would be necessary to uphold this teleconnection. The more recent record of Thorne Moors has now been destroyed by peat extraction.

Table 11

Thorne Moors: Pollen from upper four samples in Sphagnum peat (to current cutting surface)

	12 (+85 cm)	13 (+95 cm)	14 (+105 cm)	15 (+115 cm)
A.P.				
Betula	14	10	23	16
Pinus	2	6	3	5
Quercus	5	1	3	2
Alnus	14	5	20	16
Fraxinus	-	-	1	-
Corylus (Coryloid)	26	5	20	31
N.A.P.				
Gramineae	7	13	45	53
Cerealia	-	1	-	2
Cyperaceae	-	-	1	-
Ericaceae	5	10	60	79
c.f. Artemesia	-	-	2	3
Plantaginaceae	1	4	-	-
Plantago major/media	-	-	1	-
Plantago sp.	-	-	-	2
Chenopodiaceae	1	1	3	1
Compositae	-	1	3	1
Rumex	-	-	-	3
Urtica	-	-	4	1
Ranunculaceae	-	-	-	6
Typha latifolia	-	-	-	2
Potomogeton	-	-	-	1
Sphagnum	58	53	68	180
Filicales	2	2	20	5
Polypodium	-	2	-	-
No. of traverses:	33	35	16	10

(preservation progressively poorer, particularly in 14 & 15)

(for location of samples, see fig. 66)

Discussion : the flooding mechanism

The preservation of a complete forested environment beneath peat tends to invite catastrophism in interpretation. From Noah, the deliberate felling by the Roman army invoked by de la Pryme (1701) - a telescoped anthropogenic explanation containing more than a grain of truth - to the more eccentric writings of some modern authors (e.g. Velikovsky, 1958), prone sub-fossil trees, often with a preferred orientation, suggest the events of one or a series of particularly disastrous storms resulting in inundation. In geological terms, the events on the Hatfield Levels towards the end of the Middle Bronze Age were rapid but the insect evidence favours a cumulative process of flooding, which would probably have been scarcely perceptible to a single human generation and have been remembered more in terms of a collective folk memory. The extent of changes associated with the Thorne Moors episode is uncertain. On Hatfield Moors, a few kilometres to the south, established as a Sphagnum bog during the Atlantic period, a phase of increased surface wetness, close to the zone VII(b)/VIII boundary (Smith, 1958), probably correlates with the initiation of the Thorne Moors complex but the initial phase was not noted in the Thorne Waterside succession which straddles the event (Buckland, unpubl.). On Thorne Moors, the peat provides no conclusive evidence for actual flooding rather than a rising water-table, but the sediment laden character of the modern rivers entering the lower part of the Vale of York is itself a product of forest clearance and increased surficial erosion. The possibility of the infiltration of relatively silt-free waters into the forest and wetlands therefore cannot be excluded; the rising water-table would ensure that any ponds so created could remain for progressively longer on the forest floor, contributing to the decline of the trees.

The rising base level must relate, at least in part, to the penetration of marine and estuarine conditions into the Humber with the post-Glacial rise in sea level (Gaunt & Tooley, 1974) but, despite the fact that the base of the peat lies over 4 m. below current high water at Goole (+ 4.6 m. O.D.) (Yorkshire River Authority, pers. comm.), 6 km. to the north of the site, no estuarine influence is detectable in the succession. This contrasts with the Ancholme valley, where in a similar situation 13 km. from the Humber, an uninterrupted sequence of estuarine silts was laid down from c. 2,500 B.P. (Buckland, in press) to the building of Ferriby Sluice in the late eighteenth century. The catchment of the river Ancholme, however, the dipslope of the Middle Jurassic and the Chalk scarp, is slight compared with the major rivers draining into the western half of the basin, ultimately from the Pennines. The Ouse and its tributaries drain 8,913 km^2. (3,447 sq. miles), the Trent 10,572 km^2. (4,082 sq. miles) and the Don and other rivers of south Yorkshire and Humberside 5,222 km^2. (2,021 sq. miles), a total of 24,707 km^2. (9,550 sq. miles), over a quarter of the land surface of England. The scale of the current outfall is of the order of 2123 x 10^7 litres (467 x 10^7 gallons) per day, rising to 2954 x 10^8 litres (65 x 10^9 gallons) per day in flood (Radley & Simms, 1971). The present flow regime is much influenced by the embanked and constrained nature of the river courses and tidal influence reaches up the Ouse for 60 km. from its confluence with the Trent, almost to York, up the Dutch River and Don to Sandal Lock, 26 km. above Goole, and up the Trent to Cromwell Lock, 80 km. from its mouth. As Radley and Simms (op. cit.) note, however, when flooding occurs, the waters of the estuary have a secondary role, backing up the freshwater runoff and increasing the intensity and duration rather than creating an influx of saline conditions. The engineer John Smeaton, writing in 1776, in a report on

Hatfield Chase, summarised the problem,

> "the Evil attending the Drainage of these Levels, does not so much consist in this, that the Water cannot be got off from the Surface in dry Seasons, but that the Rains send down so great a Quantity of upland Water, by the Course of the River Torne, during the Winter, which overflowing the Banks thereof, makes its Way over and upon the Surface of the Levels..."

The Torne is a small river draining the Magnesian Limestone dipslope, and its problems are those of a microcosm of the entire basin; the combined effect of several of the major rivers in spate, plus backing up of the outflow by storms in the North Sea, can result in floods as that of 1625, which reached 10.54 m. (34.58 ft.) O.D., drowning the greater part of the Vale of York and Hatfield Chase (Radley & Simms, 1971). If Gaunt and Tooley's (1974) data are sufficient, sea level at c. 3,000 B.P. was oscillating just below O.D. in the North Sea Basin, after a gradual rise over several thousand years from -5 m. O.D. and a similar situation to the present may have pertained. It is apparent that a critical position had been reached between the various regimes, leading to widespread expansion of wetland habitats. Although there are some analogies with the present artificial balance, the effects of forest clearance and the tidal element are difficult to assess. In the Humber Estuary, the operative factor in controlling the tidal pattern is the presence or absence of the sand spit at Spurn. Its absence increases the access of north-easterly gales and these are the most destructive, causing excessively high tides and backing up the outfall. De Boer (1964) has traced the process of construction and breaching of Spurn Point and its precursors back into the Middle Saxon period from documentary sources but it would be unwise to assume its influence any earlier, when the mouth of the Humber would have been several kilometres further east. Certainly by the Late Bronze Age, tidal influence extended beyond the gap in the Wolds cuesta at

Ferriby (Smith, 1958; Buckland, in press) and increased tidal effects were probably a factor in flooding.

Currently the problems with freshwater runoff are being exacerbated by underdrainage of fields and extensive gripping of upland peat moors, increasing the speed of rainfall runoff (Radley & Simms, 1971). An extensive forest cover acts as a control on flooding, reducing the amount by transpiration, depressing the water-table and slowing the process of feed into the river system. In an extreme case, the effects of uncontrolled and indiscriminate clearance are well illustrated in semi-arid regions where the balance is even more precarious. In the Baringo district of northern Kenya, clear felling and logging operations in the Kamathia Hills have reduced the Ndau river from a permanent stream supplying extensive floodplain agriculture to an intermittent and unpredictable source of flash floods carrying a large volume of sediment. In Temperate Zones, the problems are proportionately less severe but the effects on the geomorphology are often underestimated. The period between upland clearance and the expansion of blanket bog with its compensatory, if less effective, sponge effect would have been one of particular propensity to freshwater flooding in the Humber Basin and this would have been a significant factor in the irreversible progression to fen and raised bog on Hatfield Chase. It is probably the anthropogenic element which gave a fen environment to this area, in contrast with the once extensive estuarine finger which crept up the Ancholme valley. This thesis is, however, difficult to substantiate with the currently available evidence and any correlation between upland and lowland events in the basin requires more absolute dates and stratigraphic examination.

Both palynology (Smith, 1958; Turner, 1965) and aerial photography (Riley, 1973; fig. 86) suggest extensive clearance of the

Permo-Triassic outcrop and overlying Drift deposits by the Late Iron Age but the dearth of stratified finds and the blanket of peat makes the earlier story extremely fragmentary (above p. 143). The principal sources of floodwater, however, lie on the Pennine watershed, where, in some shallow basins, peat formation had begun on a large scale by zone VII(a) (Conway, 1954). Generally and particularly on slopes and interfluves blanket bog tends to be a product of the sub-Atlantic, after the demise of the forest cover (Smith, R.T., 1972) and the retention of runoff by peat would be a cumulative process dependent upon depth and degree of saturation, allowing a considerable period over which runoff might have increased to the extent that a tenuous equilibrium with lowland clearance and rising sea level was overtopped, resulting in extensive and frequent intrusion of fresh floodwater into the Humberhead Levels.

Although in the Highland Zone, man may have hastened a naturally occurring progression (Ball, 1975), events in the Lowlands cannot be paralleled under similar temperate conditions in previous interglacials, although this may testify to the relative uniqueness of each cycle or the state of research. Hatfield Chase is not alone in experiencing extensive change during the late sub-Boreal and elsewhere the character of the transition would appear to be much influenced by human pressures. In the valley of the Warwickshire Avon, Shotton (in press) has noted widespread and radical alteration in the character of the alluvium of the floodplain, a rapid transition from grey reduced silts with abundant organic remains to the oxidised deposits of the current depositional regime, which took place during the latter half of the Bronze Age. This change probably relates to a critical point in clearance introducing more soil to the river. A climatic parameter may be sought but Limbrey(pers. comm.) has suggested a widespread shift over to the cultivation of winter wheat, leaving large

expanses of ground open to erosion. Such a division of the sediment can be traced in many of the river valleys of Britain, including those of the Humber Basin and, had the occurrence been synchronous across the country, it could be invoked, a few kilometres from the actual channels of the rivers, as a contributory mechanism to the initiation of Thorne Moors. At Sandtoft, however, in the former bed of the Don, the change in the alluvium overlies a phase of local coarse sand erosion with Romano-British pottery and, although it may be relevant to post-Roman flooding (Radley & Simms, 1970) and the apparent discontinuity between Roman and later farming activities, the Moors had progressed to blanket bog by this stage. A similar section, at Thorne Waterside, also in the Don, where the transition brought in sediment indistinguishable from recent warp, is undated.

The initial waterlogging of the forest soil by a rising water-table may also have an anthropogenic component. Moore (1973) has discussed the role of man in the spread of upland blanket bog in Wales and it is apparent that some lowland wetlands may have been similarly influenced. The aspects of forest in water conservation and the hydrological cycle are much debated topics (e.g. Molchanov, 1960), but it is established that closed forest results in a considerable depression of the water-table. Even partial felling may be sufficient to bring the table up to the surface (Remezov & Pogrebnyak, 1965) and kill any remaining trees, particularly in areas with a rising base level. Thus the temporary clearances noted at Thorne may themselves have contributed to the succession to a fen environment.

Whilst the discussion has concentrated upon the anthropogenic factors in the development of the Moors, these have to be viewed against the backdrop of an inexorable rise in sea level; man inadvertently deflected the nature of the hydrosere rather than controlled it. The flow diagram (fig. 67) attempts to summarise this mosaic of ideas.

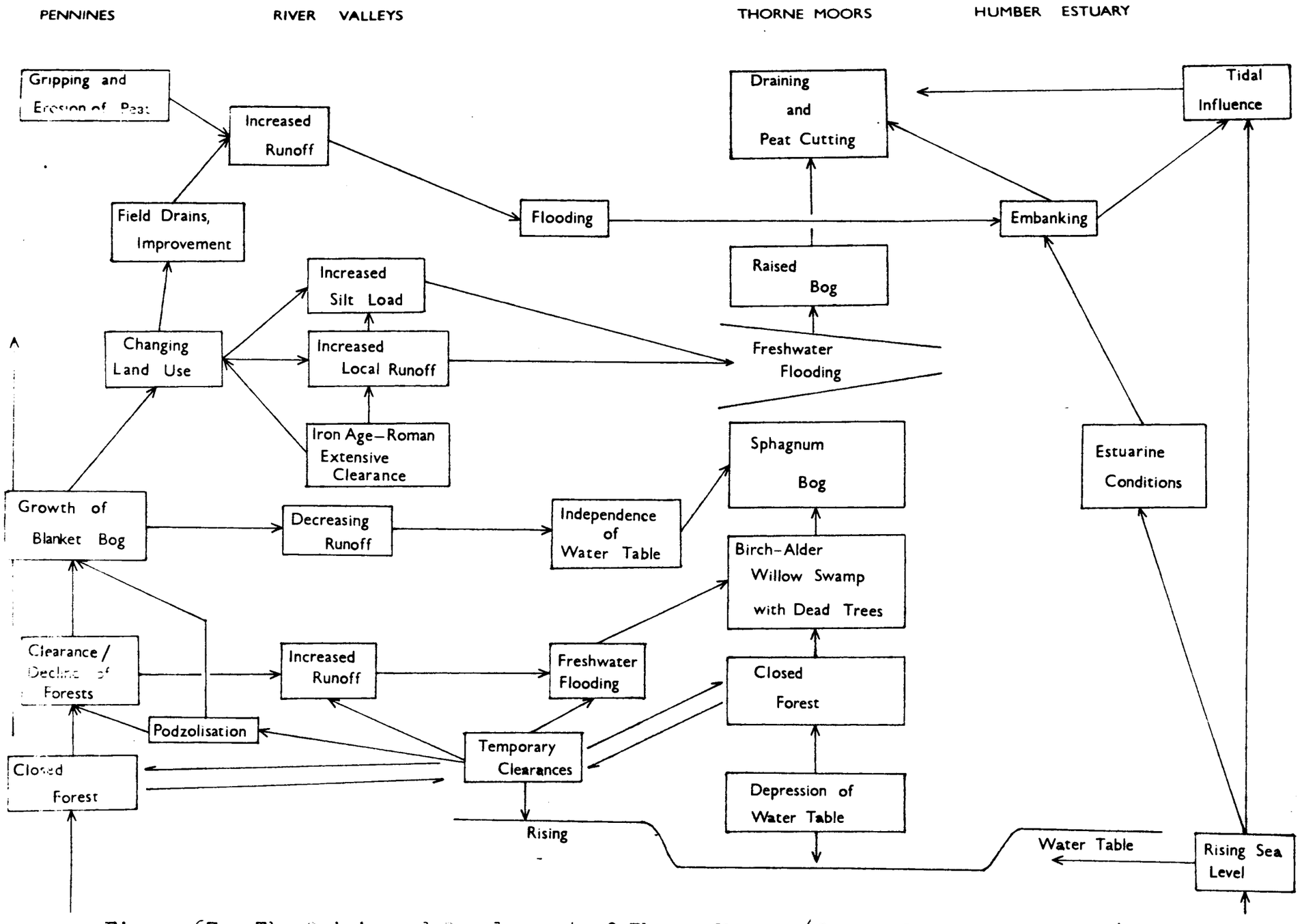

Figure 67. The Origin and Development of Thorne Moors (for explanation see text).

Notes on Particular Species

The occurrence of several insects which are no longer found in Britain and of many others having a very restricted native distribution in the Thorne Moors samples requires explanation in terms of environmental change, climatic oscillation or both. A uniform interpretation of the changing patterns of all taxa, however, is not possible. Several species show contradictory changes, with retractions both northwards and southwards occurring in the same faunal unit. Frequently the published distributional data and habitat information are grossly inadequate for the conclusions which have to be based upon them, yet, if any advance is to be made in the study of the development of the insect fauna of Britain during the post-Glacial, the scattered sources have to be collated and reasons for faunal variations through time suggested. More than ten years ago, Osborne (1964) recognised that the effects of man on the insect fauna were as profound as his effects upon the flora. The influence of man and climate become progressively more interwoven and inextricable from the early Neolithic onwards. Hammond (1974) has recently reviewed changes in the beetle fauna, with particular emphasis on variations since more systematic recording began, and he favours anthropogenic agencies for the majority of changes within historic times. Osborne in several papers (1965: 1969; 1972; 1974) has examined the problems of a number of sites and of individual species in deeper perspective, introducing evidence for both climatic and human influence in the Flandrian. With the Thorne identifications, a more adequate amount of data has been accumulated to attempt a more detailed review of events since pollen zone VII(a) and, having set out habitat, distribution and interpretation for individual species, a synthesis is attempted, although Hammond's (1974) caveat has to be considered at all stages:

"our knowledge of the present-day fauna is an inadequate basis for any discussion of past change."

The specific notes are divided into four sections: the species not presently recorded from Britain, found in the Thorne assemblages, are discussed first; secondly, the more significant of the Thorne insects with restricted British distributions are considered. To consider Thorne Moors in other than a local context without some reference to other finds of non-British species would be parochial, if not misleading, and additional information is provided on published records of pollen zone VII or later finds. Comments on other records of insects with curtailed British distributions with fossil examples known from localities on Hatfield Chase or North Lincolnshire (Buckland, in press) appear in the fourth section, as well as notes on two species of dung beetle, which are now probably extinct in this country.

Species not recorded from Britain

Rhysodes sulcatus F.

A single thorax of this species (fig. 68) was recovered from Sample 3. It has previously been recorded from a somewhat older deposit at Shustoke in Warwickshire (Kelly & Osborne, 1963), dated to 4830±100 B.P. (NPL 39) and a site at Alcester in the same county, dated by pollen analysis to zone VII (c. 7,500 - 2,500 B.P.) (Osborne, 1965). The species is now extremely rare. Absent from Britain, it was recorded last century from the southern tip of Sweden in Blekinge province and possibly also from eastern Smaland, immediately to the north, but is now regarded as extinct there (Palm, 1959). The few German records are also old: from Sollinger Wald in southern Hanover (1848) and around Munich in southern Bavaria (1851); in 1919 Novotny noted it, sometimes in large numbers, beneath bark in Upper Silesia

(Horion, 1941). R. sulcatus is now largely a south-east central European species, known from south-west Russia, Poland, Transylvania, Slovakia and the north Balkans, extending in a few scattered localities westwards to Lombardy, Tuscany, southern France and the Pyrenees and eastwards to Anatolia and the Caucasus. The ecology of the animal is poorly known but it appears to prefer beech woodland (Horion, 1935) and lives in thoroughly rotted wood. Novotny's records were from under damp bark on old rotted copper beech, although Palm (1959) notes an old record from spruce and Auber (1960) notes it in the Pyrenees from rotten fir. The closely related and equally rare R. germari Ganglb. has also been found associated with beech (op. cit.). The beetle has been variously regarded as a predator or a fungal feeder, the latter being the more generally accepted (Crowson, pers. comm.). The insect may not be as stenotopic as the records from beech imply, since all the fossil records are earlier than the appearance of a continuous trace of Fagus in pollen diagrams, at the beginning of zone VIII. As Godwin notes, however, this tree tends to be strongly under-represented in pollen diagrams (Godwin, 1975) and macrofossil remains show it to have been established at least in local stands south of the Wash in zone VII(b). It remains uncertain whether it extended as far north as Thorne at this time and the loose association of R. sulcatus there is with oak.

Belonging to a small family of only two genera, species of Rhysodes have a worldwide distribution, occurring, as well as in Europe and Western Asia, in India and Burma (Arrow, 1942), Japan (Winkler, 1932), Australasia (Broun, 1881), South Africa (Arrow, 1942), Madagascar (Fairmaire, 1868), Brazil (Guerin, 1953) and North America (Arrow, 1942). K. Dorn first proposed the term 'Urwaldrelikt' for this species in present day Europe (Horion, 1935). An apparently primitive group

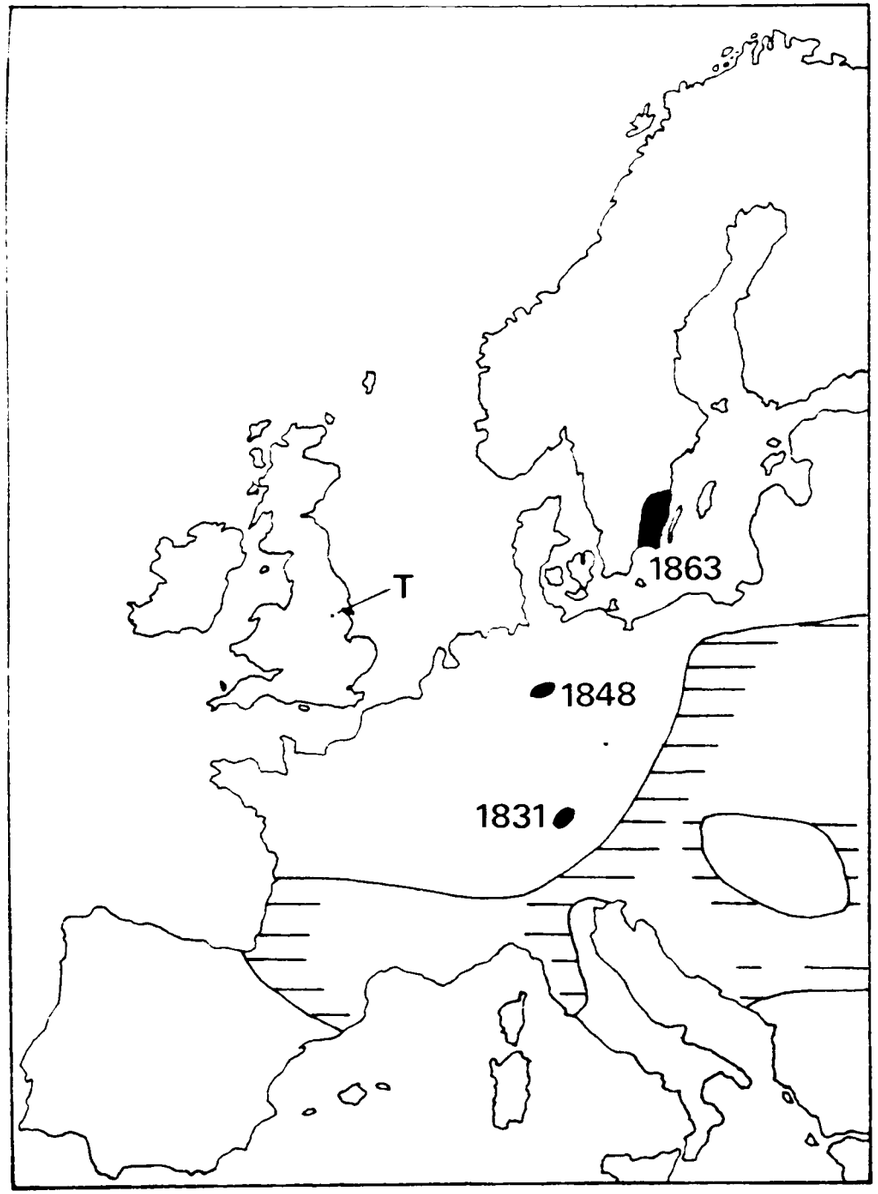

Figure 68. Rhyscoba sulcatus (dates of last records from outlying localities indicated.)

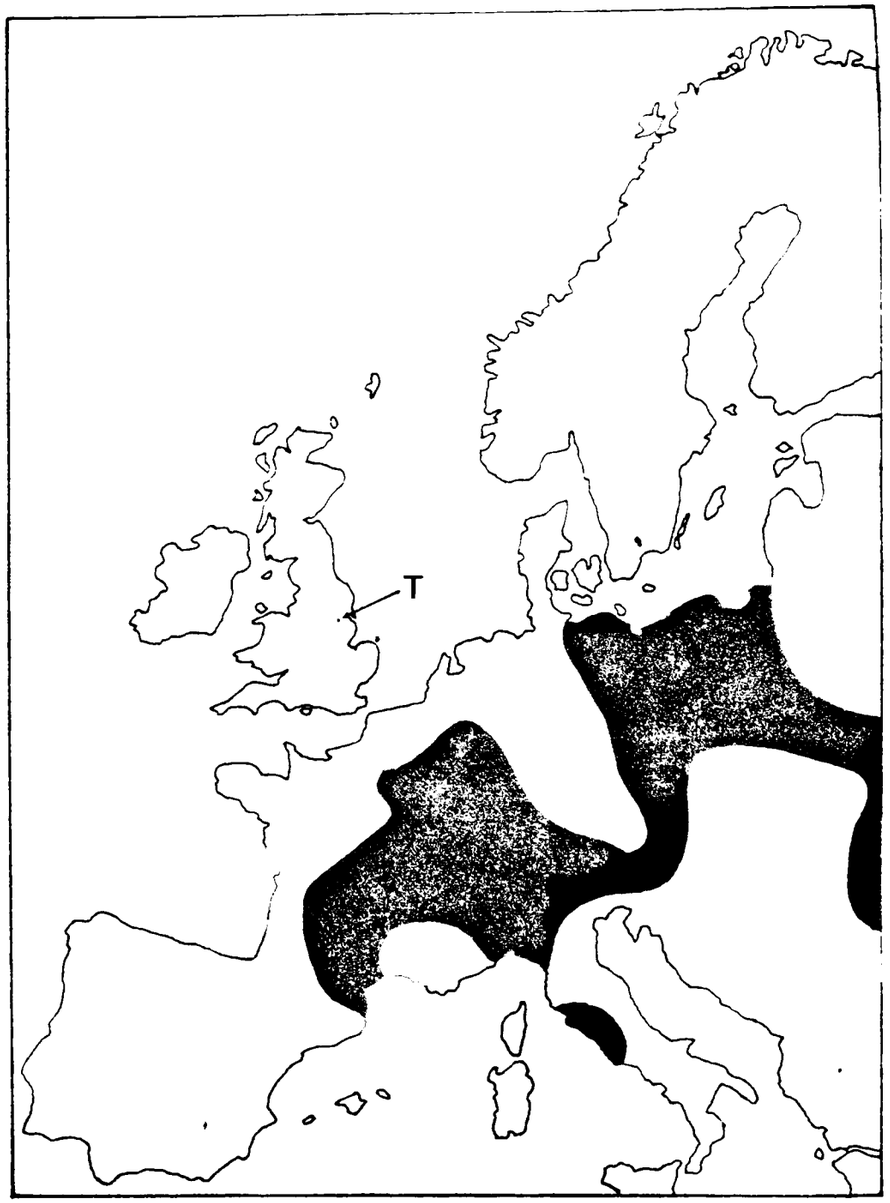

Figure 69. Isorhipis melasoides.

amongst the Adephaga the distribution of this family gives the impression of being itself a relict in the Quaternary. When the material for study is finally forthcoming, it is probable that this family will be shown to have a long history in the warmer, more species rich forests of the Tertiary.

Zimioma grossum (L.) (frontispiece)

A single complete male of this large Ostomatid was found, still in its pupal chamber, in a small decayed birch, less than 10 cm. in diameter, at an horizon a few centimetres above that of the track-way but 500 m. further east in the dyke section. Several other birches were noted in the fresh ditch sections at roughly the same level and they seem to represent a slightly drier phase in the development of the bog, allowing the spread of trees onto the surface, somewhat like the birch scrub which occupies the Moor at the present day, a result of increased drainage activity. Zimioma grossum has a boreo-montane distribution ranging across Europe from Scandinavia and East Germany to the region of Lake Baikal in Russia. Another species, Z.giganteum, distinct on the aedeagus, appears in Siberia, Horion (1960) records the species living in Central Europe beneath the bark of rotted spruce and fir, although there are also records from Upper Silesia and Banat from under rotten beech bark. The beetle is likewise not recorded from birch in Finland but in Sweden it occurs in thick, dry birches with soft rot, which develops particularly after felling in trunks and stumps exposed to the sun (Palm, 1951). The association of this insect with Urwald damaged by forest fires is interesting in the light of the evidence for slash and burn agriculture at Thorne and the suggested widespread use of this method of clearance (e.g. Bender, 1975), which would have provided abundant habitats for this and several other species which are attracted to burnt ground. With the

spread of more permanent methods of land utilisation, these habitats would have been gradually curtailed.

Isorhipis melasoides

As well as the seven well preserved individuals of this Eucnemid (fig. 69) recovered by splitting wood samples from the brushwood peat, the characteristic workings and larval head capsules were noted in several other pieces of timber, implying that the insect was, at least locally, abundant in the Middle Bronze Age on the Hatfield Levels. An undated example, younger than the Early Bronze Age, was also recovered from the Misterton Carr succession. The beetle usually develops in beech (Reitter, 1911) but is also recorded from other deciduous timber (Escherich, 1923). It is unfortunate that no wood identifications were done amongst the additional samples from Thorne but beech does not appear in the pollen diagram (fig. 66) until above the trackway horizon and then only as single grains, perhaps of distant origin. Godwin (1975) notes that macrofossils of beech occur as far north as a line from the Wash to the Lower Severn during pollen zone VII(b) and pollen evidence implies local presence as far north as the Lake District in zone VIII. As a tree more characteristic of drier, more calcareous substrates, Fagus sylvatica is unlikely to have thrived during the period of rising water table and flooding represented by the Thorne faunas and, although other predominantly beech feeders, like Eucnemis capucina, are present, it is probable that they were living in other hosts. Auber (1960) records I. melasoides in France from oak and poplar, as well as beech. If this Eucnemid does prefer beech, its retraction may predate the large scale expansion of beech forest in such areas as the Chilterns, although failure of continuity of habitat due to clearance and the intensive management of these woods during the mediaeval period could have been

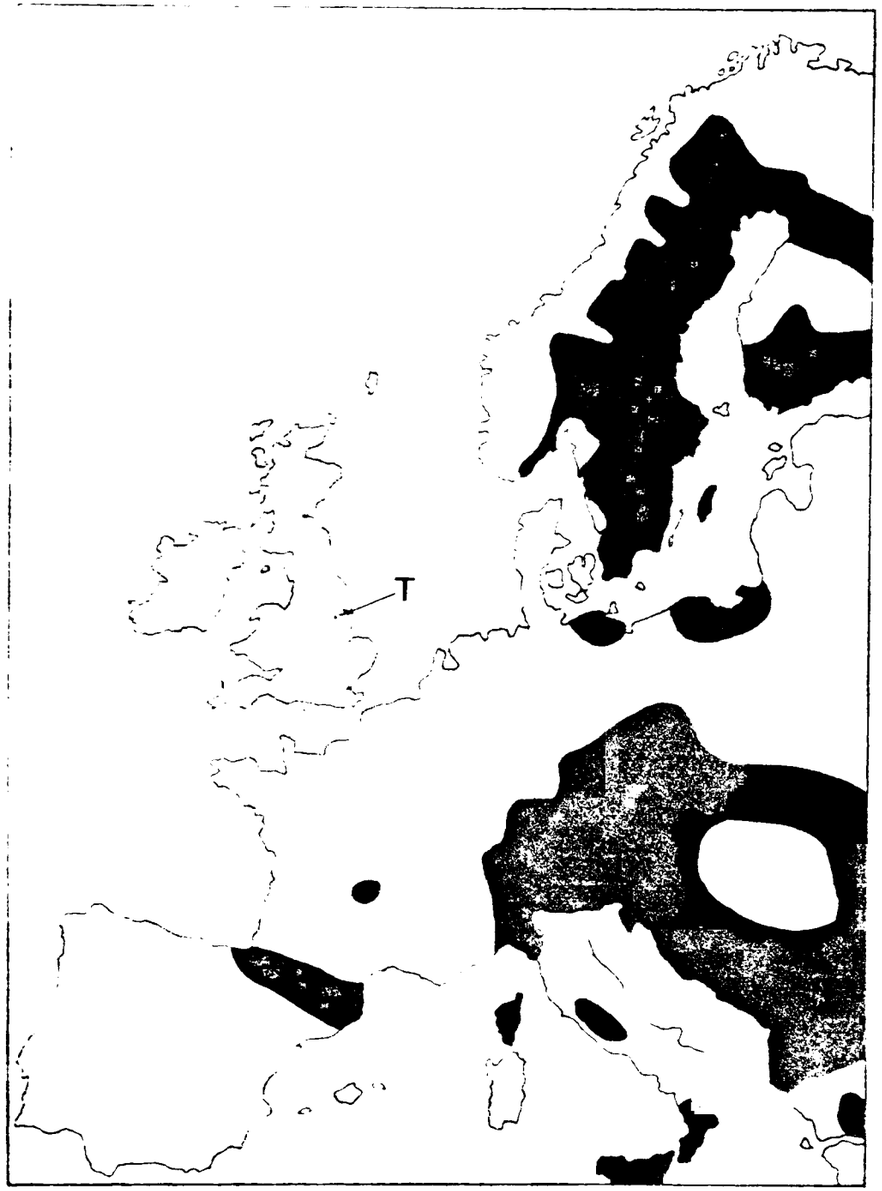

Figure 70. Zibrioma grossum.

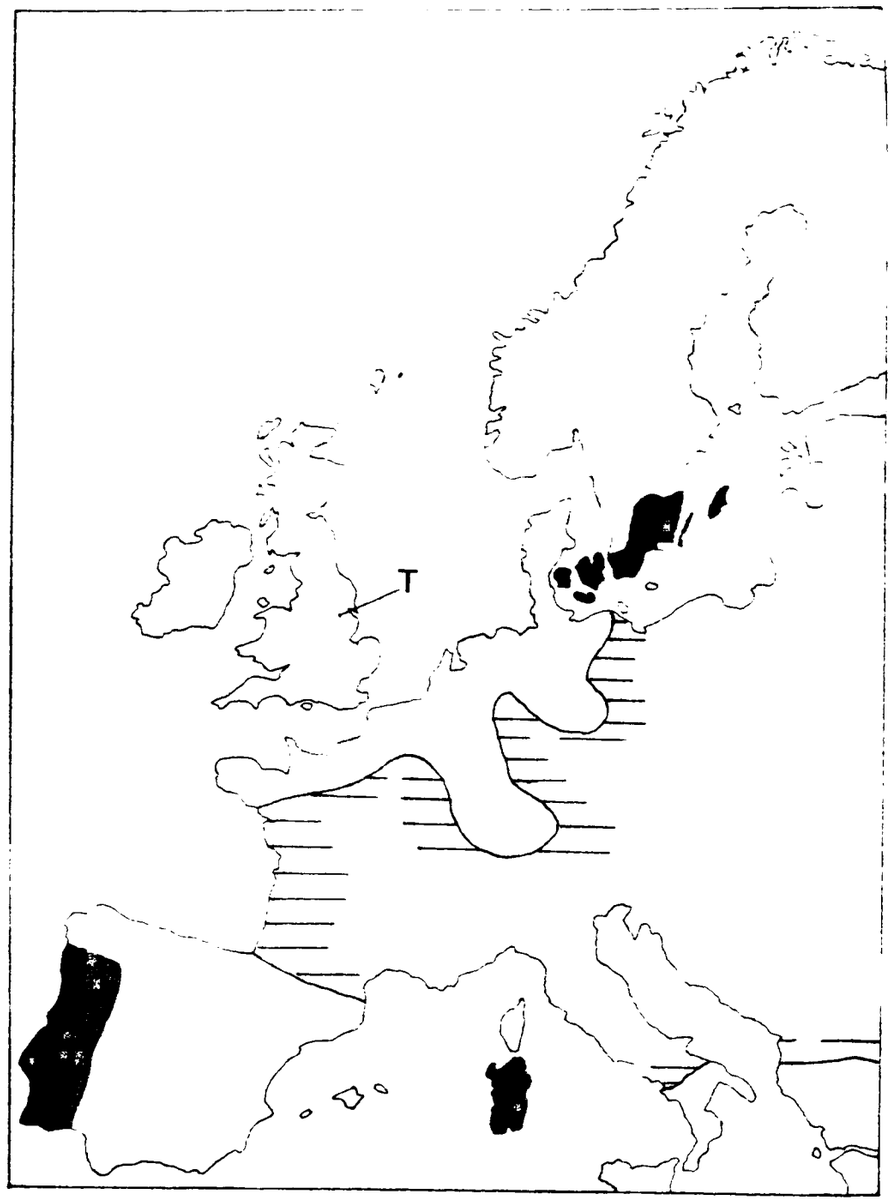

Figure 71. Prostomis mandibularis.

equally critical. E. capucina survives not in the Chiltern beechwoods but in the New Forest, where there has been less disturbance. The continental distribution, however, suggests that I. melasoides is relatively thermophilous. It is absent from Scandinavia, rare in France (Auber, 1960), avoiding the western seaboard and the Mediterranean (Horion, 1953). In Germany (Horion, 1953), it is known from the Baltic coast, Brandenburg and Silesia, and in the Rhineland, Hesse and the Alpine foreland. The absence from a broad strip across central Germany implies that its distribution may not be simply climatic and old, established forests would also appear to be essential for its survival.

Prostomis mandibularis (F.)

Amongst the species no longer found in Britain recovered from the Thorne Moor samples, P. mandibularis (fig. 65) is the most frequent, with a total of fity-six individuals from the trackway horizon. It has yet to be recorded from any other site in Britain. Both Horion (1960) and Palm (1959) use the term Urwaldrelikt for this beetle and, although primarily recorded from damp, very rotten oak, it is also known from beech and pine (op. cit .). Large numbers of individuals may occur in a single piece of timber, often between the annual rings, which have been loosened by fungal attack. As Horion notes (1960), it is very much an animal of the Urwald, the primary, undisturbed natural forest, and is very much restricted to only a few isolated strongholds in the remnants of Central European primaeval forest, from which it is rapidly being ousted by tidier forestry practice. Horion (1960) expected that this rare Cucujid would disappear completely from Central Europe within a few years and that it already seemed to be on the verge of extinction from the Harz, Thuringia, Saxony and the Palatinate. The species has a holarctic

distribution, occurring in Europe from the southern part of Sweden (fig. 71), southwards with a few localities in Denmark, through Germany into Central Europe; westwards it is known from Portugal and France, particularly in the south of the country, to Switzerland, Sardinia and Italy, south to the Bay of Naples.

Mycetina cruciata Schall.

A single thorax of this Endomycid was recovered from between the timbers of the trackway. It does not occur in Britain at the present day and there are no other fossil records. In Scandinavia, the species is very southern in distribution, avoiding the wet, oceanic west and south coasts of Norway and the mountains but occurring as far north as Dalarna and Helsingförs provinces in the more sheltered, continental eastern part of Sweden; in Finland it is restricted to the southern coast strip (Hansen et al., 1960). In Germany, this beetle tends to be eastern and southern, occurring in Prussia, Silesia, Baden and Bavaria, as well as Austria; there are also old records for Mecklenburg, Hess, Hanover, Thuringia and the Harz (Horion, 1951). Reitter (1911) notes the species from rotting wood in mountain regions. Despite its avoidance of climatically damp areas, this fungal feeder prefers very moist to wet wood in shaded localities in forests, with the wood being in such an advanced state of decay that it is rapidly crumbling into the litter on the forest floor, (Palm, 1951). The insect prefers conifers but has been recorded from most types of tree. Horion (1961) notes it to be locally common under the bark of both deciduous and coniferous trees, associated with Polyporus species.

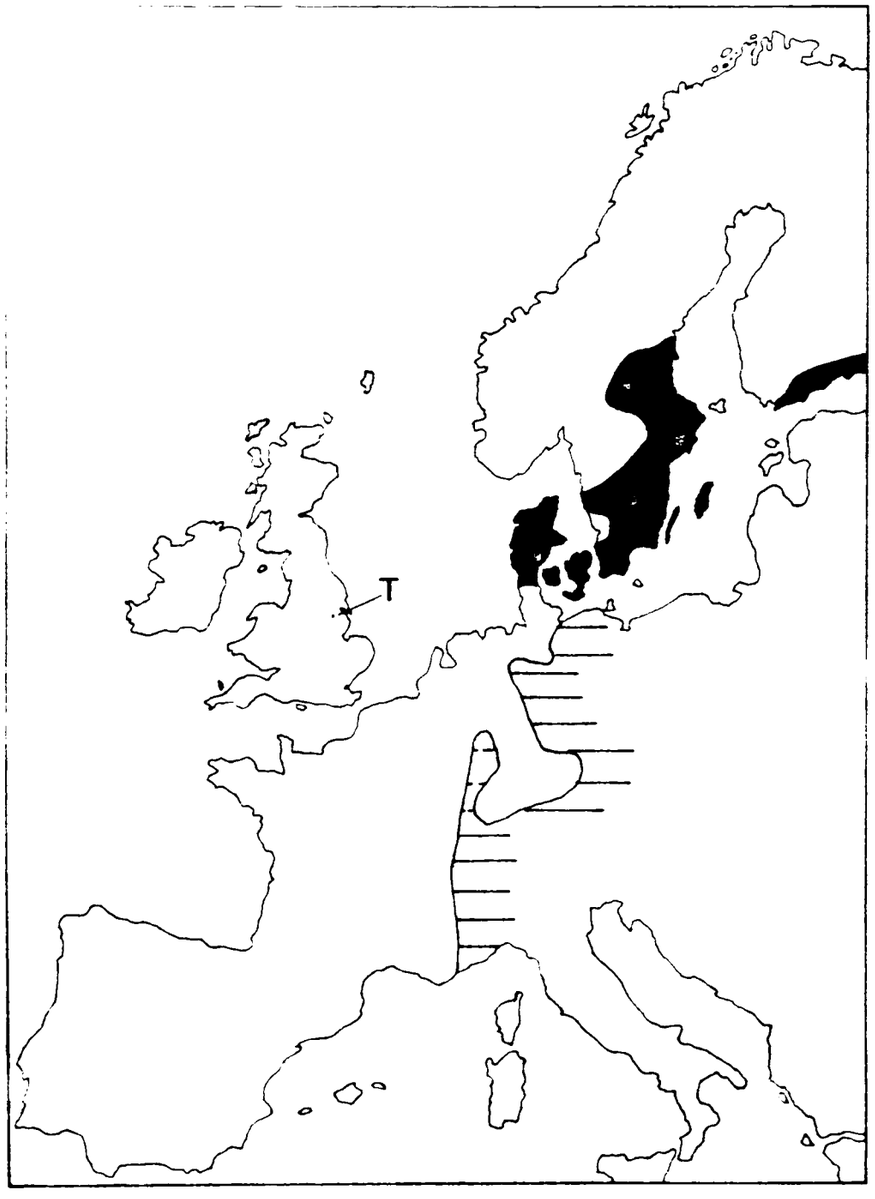

Figure 72. Lycetina cruciata.

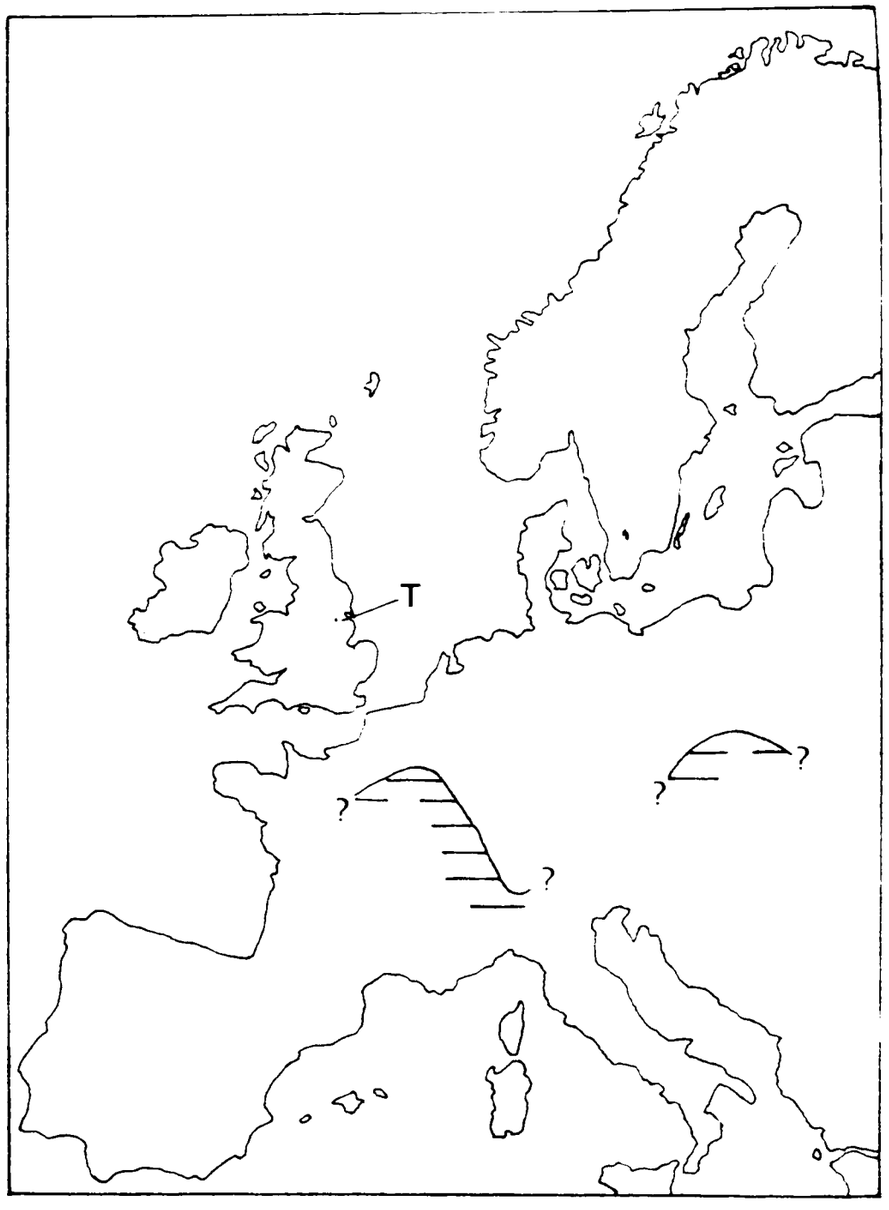

Figure 73. Encephalodontus baudeni.

Rhopalodontus bauderi

Distinguishable from R. perforatus, known from Scotland (Massee, 1967), by its larger, deeper puncturation on the elytra, R. bauderi is not recorded from either Britain or Scandinavia and Lohse (1967) notes the species from Slovakia, southern and western Europe. The Ciids are not directly associated with rotten wood but with the fungal fruiting bodies appearing thereon. In the British Museum collection, there are three specimens of R. bauderi labelled 'bred in Cambridge Forestry School (1924) from Fomes fomentarius from a beech tree in the Landes, France'. As Paviour-Smith (1969) notes, however, in discussing R. perforatus, there has been confusion between F. fomentarius, which, in Britain, is restricted to birches in the Scottish Highlands, and Ganoderma applanatum, which is more characteristic of old beeches, and it is possible that the latter is intended on the British Museum label.

Acalles sp.

A single head, close to A. roboris but more heavily punctured on the rostrum could not be matched by specimens in the British Museum collection, but there are several species in this part of the genus in Europe (Hoffman, 1954) and identification will have to await the recovery of more fossil material.

Comments on Species recorded from Britain

Agonum livens Gyll.

Although another species of this genus, A. obscurum, from the Thorne samples, is perhaps a more characteristic carabid of deciduous woodland (Lindroth, 1974), its occurrence as far north as southern Scotland, often among the moss on the bark of old oaks, (Crowson, 1962), makes it less useful from an interpretative point of view than the very restricted A. livens. This species reaches its present northern limit in Britain on Thorne Moors and at about 20 km. due west, where it is recorded from both Denaby and Edderthorpe Ings in the Dearne Valley (Skidmore, 1966; 1970). To the south, it is recorded from the Trent bank at Rampton (Carr, 1916) but, throughout the country, it is a rare and localised species (Lindroth, 1974) and its relative abundance at its present northern limit is surprising. In Scandinavia, it is largely restricted to the more continental eastern part of the oak zone (Lindroth, 1945) being absent from Norway, although there are occasional records in Finland from as far north as the northern end of the Gulf of Bothnia (Hansen et al., 1960). In Germany it occurs throughout the country but is, on the whole, rather rare and scattered, becoming rarer to the South (Horion, 1951). The species is strongly hygrophilous and Lindroth in both Scandinavia (1945) and England records it from 'marshy deciduous forests, often alder, among leaves and Sphagnum moss' (1974). The association with alder or birch in swampy areas (Lindroth, 1945) is not, however, maintained in the South Yorkshire localities. On Thorne Moor, the species was taken from Phragmites litter (Crossley, pers. comm.). Denaby Ings lies at the foot of the scarp slope of the Magnesian Limestone, sandwiched between a disused railway embankment and open, largely arable farmland. There is no woodland on the valley floor

and the insect is closely associated with old willows, usually under the loose bark of rotten willows (Skidmore, 1966) on the edges of wet, frequently flooded ings; a similar habitat is found at Edderthorpe Ings, further up the Dearne Valley. On the available evidence, it is difficult to ascertain whether this represents actual variations in habitat between Scandinavia and England, perhaps implying slight physiological adaptation, or an increased specificity in habitat towards the limits of its range, a feature noted with certain of the xylophagous species from Thorne. It is probable that the microclimate in reed swamp litter and beneath willow bark in a relatively open habitat in South Yorkshire is analagous to that in shaded fen woodland in Scandinavia, although clearly other factors may be involved and the available data is insufficient.

Hydroporus scalesianus

The drainage of the East Anglian Fens, largely completed with the disappearance of Whittlesea Mere in 1851, marked the virtual end of a series of interrelated habitats, which had once been ubiquitous in Lowland Britain. The extinction of the British sub-species of the Large Copper butterfly, Lycaena dispar L., which was restricted to the Fens, is widely known (Heath, 1974), but the radical decline in several species of Dytiscid and Hydrophilid water beetle is less frequently referred to. Stephens described H. scalesianus in 1828 from an unlocalised Norfolk specimen and it was not taken again until 1856, when it was found in Chaloner's Whin, near York (Balfour-Browne, 1940). All specimens in British collections came from this locality until it was last taken there in 1894, over-collection and decline in the habitat contributing to its demise. Balfour-Browne (op. cit.) took the species in eastern Norfolk in 1904-6 but there are few subsequent records. It must, however, have

once been much more widespread since, during pollen zone VII(b), it is recorded from Thorne Moors, the Somerset Levels (Girling, 1976) and Church Stretton, Shropshire (Osborne, 1972). As Balfour-Browne notes, its preference for swamps with thick moss and clear water probably means that it has been overlooked in many apparently suitable localities but French records (Guignot, 1933) suggest an association with woodland pools and it is this aspect of the Fens which had been most seriously depleted long before drainage (e.g. Rackham, 1974) and the few records of this insect may refer to relict populations precariously surviving in an environment marginal to its normal.

Hydroporus neglectus and H. rufifrons

H. neglectus is also recorded in France from forest pools, in stagnant water with dead leaves (Guignot, 1933), although, in England, Balfour-Browne (1940) collected it, occasionally in large numbers, from shallow ditches with much vegetation. This Hydroporine is slightly more widely recorded than the previous species and is known as far north as north-east Yorkshire and, in the west, from Flint but it has only been taken with any frequency in eastern Norfolk and Surrey (op. cit.).

Balfour-Browne (op. cit.) notes that, despite its wide range and occasional frequency, H. rufifrons belongs to a declining element in our fauna, that of true fen species. It has been recorded as common at Chaloner's Whin, near York (op. cit.)

Oxytelus fulvipes

Although there are records of this Staphylinid from as close to the Thorne Moors site as Sherwood Forest (Allen, 1964),

c. 25 km. to the south-west, it is sufficiently uncommon for some comment to be required. Allen (op. cit.) was only able to record captures from four other, scattered localities in England: Ormesby Broad, E. Norfolk, Needwood and Sutton Park, Staffordshire and Tonbridge, Kent, O. fulvipes occurs among dead leaves and other litter in wet situations and may have been overlooked in more northern localities but its Scandinavian distribution, absent from Norway except the Oslo-district (Hansen et al., 1960), suggests a preference for a more continental regime and it may be regarded as having a relict status in England.

Ilyobates subopacus Palm.

Specimens of this species in museum collections in Britain were labelled as I. nigricollis (Payk.) until Johnson (1968) pointed out that virtually all the British examples which he and A. A. Allen had examined were of I. subopacus; there are a few authentic British records of the true I. nigricollis. Comparison of the Thorne examples, represented by thoraces and elytra, with a range of both species in the British Museum shows that they belong to the smaller one with closer puncturation on the thorax - I. subopacus Palm. Both species are found in leaf litter but that found in the Thorne samples is the more characteristic of marshy places (Johnson, pers. comm.).

Plectophloeus nitidus

This small Pselaphid is extremely rare and is only known from four British localities: Sherwood Forest, Windsor Forest, Blenheim Park, Oxford and Moccas Park, Herefordshire (Pearce, 1957). All records of this insect in England are from old, rotted oak stumps and trunks (op. cit.); Donisthorpe (1939) also found it associated with the ant Lasius brunneus in a felled oak in Windsor Forest,

although the beetle need not be myrmecophilous. The Thorne specimen is closely associated with an old oak but, in Sweden, where it has only been recorded from Strömsholm, Vastermannland in central, southern Sweden, it has also been taken from limes, in company with L. brunneus (Palm, 1959). The species, perhaps in part due to its small size and cryptic habitat, is also rare in the remainder of Europe and, in Germany, is only recorded from the Rhineland, Wurtemburg, Bavaria, Brandenburg and Silesia, with old records (pre-1910) for Mecklenburg (Horion, 1951).

Microlomalus parallelepipedus

Allen (1971) regards this minute Histerid as one of our rarest insects and, apart from old, somewhat vague records from the New Forest, it has only been taken once, in 1952, near Canterbury. The species is not referred to by Joy (1932) but it is included in Kloet and Hincks' checklist (1945). In England, as would be expected with such an uncommon animal, there is little habitat data; one was collected by sweeping in the New Forest, probably around the turn of the century, and the Kent example probably came from beneath the bark of a chestnut, an introduced tree (Allen, 1971). In Sweden, it is recorded from oak and sycamore but is more characteristically found beneath conifer bark on trees attacked by Scolytids (Ips spp.) (Palm, 1959) and Reitter (1909) notes a similar preference in Germany. French records (Auber, 1960) are from beech and pine. The Thorne specimen, which includes both elytra with abdomen and aedeagus, came from between the timbers of the trackway and cannot therefore be associated with any particular species of tree. The beetle occurs throughout Germany but is rare (Horion, 1951) and in Scandinavia it is found from the Oslo region eastwards, on both sides of the Baltic as far north as 62°N. (Hansen et al., 1961).

Haplocnemus pini

In Britain, this Dasytid is associated with old pine forest and, apart from a capture in the Scarborough district of Yorkshire (Skidmore, pers. comm[1]), where it could have been introduced accidentally in the foliage of conifer seedlings, it is largely known from occasional examples taken in the pinewoods of the Scottish Highlands (Hunter, in press). Buck (1955) records single examples of the other British species, H. nigricornis (F.) from rotten birch in Epping Forest and in the index to this volume of the Entomologists' monthly magazine, this is corrected to H. pini. It has also been found under pine bark in Sweden (Palm, 1959) but is not an insect of the northern coniferous zone. In Norway, it has only been recorded in the Oslo region and, in Sweden, it does not occur north and west of a line from Västergötland to Uppland (fig.74); in Finland, the only records are from the province of Nylandia, on the south coast (Hansen et al., 1961). The restriction to a pine pabulum only occurs in the northern part of its range and, in Central Europe, its more catholic tastes are shared by another British pine feeder, the weevil, Eremotes ater, also in the Thorne faunas. Palm (1959) has taken the species by sweeping in a wooded valley with moribund oaks, limes and other deciduous trees in southern Sweden and Horion (1953) notes it frequently from oak in Central Europe, where it becomes rarer towards the north (Horion, 1951). The apparent curtailment of the British distribution almost completely to the Highland pinewoods seems most satisfactorily explained by invoking anthropogenic causes - the disruption and dispersal of its habitat - but such a hypothesis carries the important corollary that either the insect has always been restricted to pine in northern Britain or that the factors which created this increased host specificity, possibly a thermal decline, only became effective after the Middle Bronze Age, when the Thorne specimen shows that H. pini was endemic at least

[1]Specimen is H.nigricornis(F.)=H.impressus(Brit.auctt.)(Aubrook, in litt.)

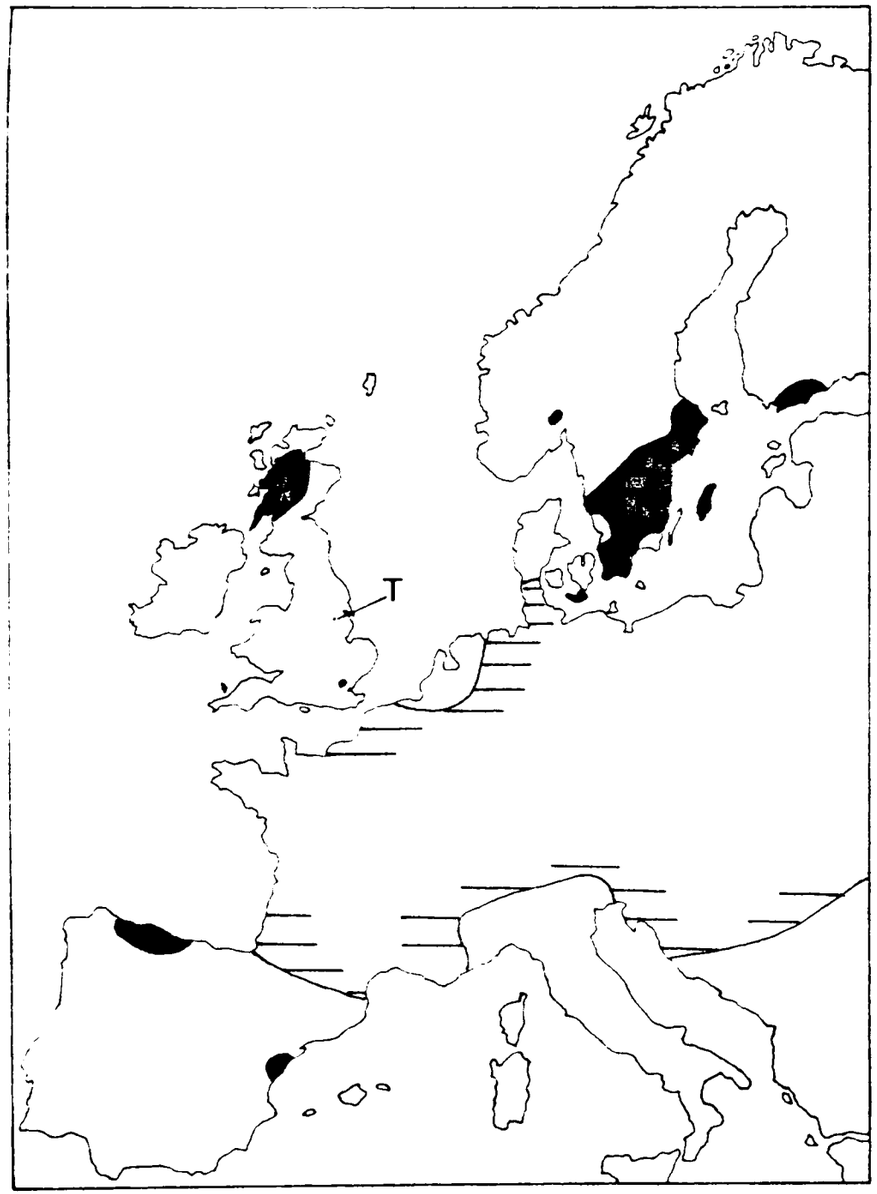

Figure 74. Eurlocomus rini

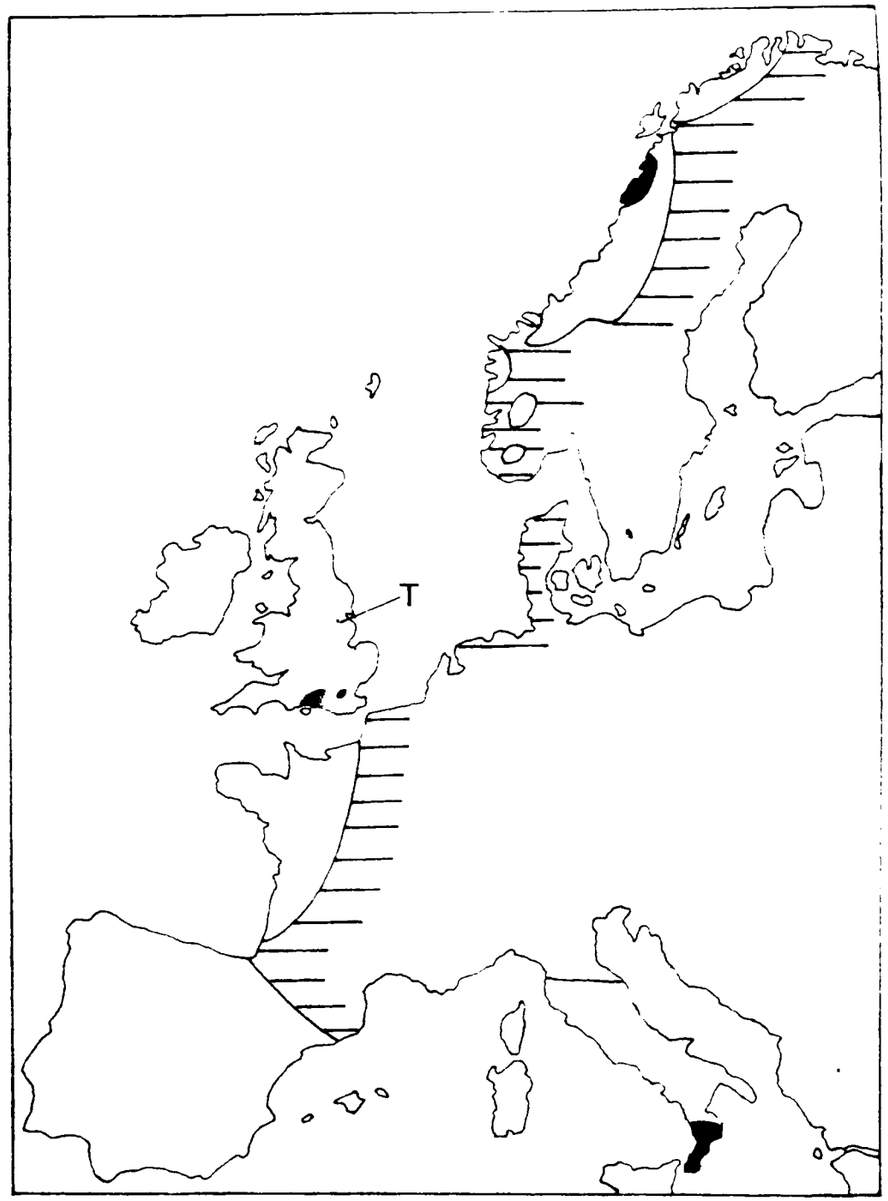

Figure 75. Dasytes niger

as far south as the Humberhead Levels. Although the distribution on the European mainland would imply that this beetle prefers a fairly warm continental climate, the Scottish Highland localities are far more oceanic than much of the intervening areas of England and Norway and, like two other Thorne species, Eremotes ater and Scolytus ratzeburgi, towards the edge of its range, it is perhaps more the long term continuity of specific habitat rather than climatic regime which is most significant.

Dasytes niger

The larvae of this species have been recorded under the bark in rotting wood of various deciduous and coniferous trees and are apparently predaceous, probably on the larvae of Diptera (Palm, 1959). Easton (1965) took the adults, in some number, on rain-drenched flowers of the common rockrose (Helianthemum chamaecistus) in southern Hampshire but the beetle is both rare and of restricted distribution in England, with records from the New Forest, Surrey, Windsor, Savernake Forest, Wiltshire (Holford, 1968) and West Sussex (Cooter, 1969). In Windsor Forest, Donisthorpe (1939) was only able to repeat Stephens' record of a capture by Leach, prior to 1830. In contrast, the species occurs throughout most of Scandinavia, including the far north, where it occurs in birch (Palm, 1951) and coastal, montane provinces of Norway (Hansen et al., 1961). It is also widespread in Central Europe (Horion, 1953). The distribution of this insect is the most contradictory amongst those of the Thorne faunas: eurythermal on the Continent yet a very southern, apparent Urwaldtier element in the British fauna. The French distribution, however, also avoids the north-west and it is absent from Iberia (op. cit.), suggesting an avoidance of the influence of the Atlantic on the climate.

Ptilinus pubescens Ahr.

In Britain, this species is only known from Windsor and the New Forest, from whence there are a few records from decaying beeches (Appleton, 1972). Donisthorpe (1939) also took a small series from an old ash tree in Windsor Forest. In Scandinavia, the species ranges north of the limit of both these trees in Västmanland, Sweden, and Savonia and Karelia, Finland (Hansen et al., 1960), where it is associated with elm and sycamore (Palm, 1959), and, in Germany, it is recorded from all species of deciduous tree (Horion, 1953). The species is regarded as a rare Urwaldrelikt by Palm, who studied its biology extensively in Strömsholm district, Sweden. The larvae develop inside the hard surface of the rotting timber, pupating in autumn, and the adults emerge the following spring but remain within the pupal chamber until stable, warm summer weather appears (op. cit.). Such a species would therefore be particularly susceptible to a spell of early warmth followed by late spring frosts.

Trinodes hirtus

This small Dermestid is recorded from Windsor Forest (Donisthorpe, 1939), where both imagines and larvae were taken from cobwebs under oak bark. The species was not uncommon and adults also occurred on ledges by deer pens, in hollow trees and on oak branches. In Scandinavia, it has been recorded from most species of coniferous tree, as well as oak, elm and hornbeam (Palm, 1959). The beetle is a general scavenger of insect remains in trees, being attracted by these to spiders' webs. *T. hirtus* is generally distributed in Central and Southern Europe but rare, occurring also in the Caucasus and east of the Caspian Sea (Horion, 1955). Its northern limit lies at the southern tip of Sweden, occurring in Skåne, Blekinge, Halland, on

Öland and Zealand, and on the Danish peninsula (Hansen et al., 1961). Despite its occurrence in synanthropic situations in Germany (Horion, 1955), unlike other Dermestids, T. hirtus seems to have been unable to exploit the artificially cushioned habitats created by man to maintain or increase its range.

Rhizophagus parallelocollis (Gyll.)

Apparently distributed throughout Britain, this species forms one of an interesting group of possibly basically forest species, which also includes Cryptolestes ferrugineus and Xestobium rufovillosum, discussed below, which have been able to adopt to varying degrees, synanthropic habitats. R. parallelocollis is found occasionally, if rarely, both behind damp bark and at sap on deciduous trees (Horion, 1960) but is most frequently taken from graveyards. Johnson (1963) records it, with R. perforatus, also in the Thorne samples, from compost heaps and vegetable debris as well as in fungi and on carcasses. It has been found in sub-fossil contexts in a medieval burial from London (Stafford, 1970), in the tomb of Archbishop Greenfield (ob. 1316) (Buckland, in prep.) in York Minster, in the Roman sewer in York (Buckland, 1974) and on the Anglo-Danish site at Lloyds Bank, York (Buckland, unpubl.). All three principal biotopes recorded by modern authors are therefore represented, although the Thorne specimens could have been in rotting plant debris in the trackway and at the base of tree 1, rather than behind its bark. There is some discrepancy in the suggested food sources for this beetle. Megnin (1894) noted it preying on Phorid larvae in corpses less than two years old, Palm (1959) thought that it lived on the fatty tissue, whilst Horion (1960) regards it as a mould feeder. Blair (1922) regards it as a predator. It is both difficult and

hazardous to argue from the fossil evidence but the closed system provided by the Greenfield tomb is of some significance. Kraatz and Heyden (1888), quoted by Horion (1960), were of the opinion that R. parallelocollis lived on the mouldy wood of the coffin and not the corpse. Greenfield, however, interred in his robes in a lead coffin inside a stone sarcophagus, had very little associated wood. The tomb allowed the body to dehydrate slowly, reducing everything, except some of the bones and some fabric, to a black organic residue on the base of the lead coffin; the burial, however, was sufficiently sealed and anaerobic to preserve perfectly the insect remains and drying out probably occurred through the pores of the limestone coffin. It would have been virtually impossible for the included insect fauna to have entered the coffin after interment although Blair's (1922) evidence suggests that newly hatched larvae could enter coffins, and moulds which would grow on the decaying body might also be expected to attack the insect remains. Although it should be noted that a few individuals of a known mycetophage, Mycetaea hirta, occurred, it seems unlikely that there was sufficient mould growth within the coffin, whose lead lining would in any case inhibit this, to support the very large numbers of Rhizophagus which occurred in the Greenfield samples. This entire fauna, dominated in the preserved remains by R. parallelocollis and the carnivore/omnivore Quedius mesomelinus, must stem from eggs laid on the corpse whilst the Archbishop lay in state, when there would also have been some opportunity for mould growth. The system, phorid eggs plus those of predators on these flies, seems the most probable, the predators utilising the fatty tissue secondarily by consuming the maggots. It may be significant that the Greenfield samples suggest that few coffin flies reached the pupal stage, although the deposit was packed with adult Rhizophagus and Quedius, although this could be a factor of preservation.

The change from either a predatory or mycetophagous species of vegetable debris and behind bark to the direct utilisation of putrefying fatty tissue implies physiological change, or at least a specialisation, in this species which isolates it from the remainder of the genus. In view of the proven morphological stability of many species during the Post-glacial and earlier (c.f. Coope, 1970) and the general concordance between modern and fossil habitat data this seems an improbable, if interesting, possibility. It is most probable that the beetle is able to find the same food source behind bark, in plant debris and in corpses. The mould flora of plant decay differs from those associated with animal putrefaction and, although a generalised mould feeding is possible, the available evidence would best support predation on larvae; more research, by direct observation, is needed. The specimens from the Roman sewer at York (below p.337), seem to have formed part of the resident sub-terranean fauna and are associated with large numbers of Psychodid fly puparia (Telmatoscopus spp.); predation on these seems probable, although mould feeding cannot again be wholly ruled out.

It is interesting tonote that there are no recent records of R. parallelocollis from South Yorkshire, although it is recorded from old hawthorn stumps at West Ayton in North Yorkshire (Walsh, 1956). Although the more natural habitats remain freely available, more rigorous requirements from the Department of Health for burial grounds has severely affected churchyard populations and careful searching failed to produce specimens from new or old graves at Tickhill, south of Doncaster.

Cartodere separanda

Until 1966, when Allen published a key to separate them, this species was largely confused with C. elongata Curt. and all the Donisthorpe and British Museum specimens of the latter were found to be C. separanda by Allen. In several sources, including Kloet and Hincks (1945), the two species are synonymised but both Allen and Lohse (1959) describe significant differences in the aedeagi and the curvilinear form of the sutural margin over the elytral declevity in C. separanda is a useful diagnostic character for fossil examples, although one of the Thorne specimens is supplemented by an aedeagus. Because of the confusion of these two species, it is difficult to obtain distributional data. Hanset et al. (1961) record C. separanda in Scandinavia only from around Oslo and Blekinge province in south east Sweden but Strand (in Allen, 1966) noted that the two were mixed in his Norwegian collection. In England, C. separanda would appear to be the more common, although the relative frequency of specimens may well reflect its more gregarious nature. Allen's (1966) list of localities records both species as far north as Sherwood Forest, although there is a gap of nearly 150 km. between these occurrences in this relict forest region and the nearest other localities in the South-East, where the species recovered in the sample from the base of the oak (tree 1) has been taken in scattered localities north into Hertfordshire. Isolated findspots occur further west, in the New Forest and at Bovey Tracey, Devon. In part this distribution must relate to the relative frequency of collectors but it is surprising to note that the few examples in the Doncaster Museum collection belong to the other species, C. elongata.

Colydium elongatum

A predator in the galleries of wood-boring insects, C. elongatum is only known in Britain from scattered records for the New Forest (Joy, 1932). In Scandinavia, it is only known from southern Sweden (Hansen et al., 1960), where Palm (1959) records it from beech and spruce. Its apparent preference for these trees, as that of its congener, C. filiforme F., as yet not recorded from Britain, noted in Sweden exclusively from old oaks, may be more a factor of its relative rarity than actual and, in France, (Auber, 1960) and Germany (Vogt, 1967) it may occur under the bark and in borings in any species of tree.

Teredus cylindricus Ol.

This Colydiid had only been recorded from Sherwood Forest, Nottinghamshire until Donisthorpe (1926) took it in Windsor Forest, where it appeared to be not uncommon. On the Continent its distribution is equally disjunct, occurring on the Swedish island of Öland, on Bornholm (Hansen et al., 1960), in southern Germany and Austria with old records from the Lower Rhineland, Thuringia and Bavaria (Horion, 1951). Usually found in old oaks, it is also recorded from old beeches (Reitter, 1911) and lives as a predator in the galleries of Xestobium rufovillosum, Anobium punctatum and Dryocoetes villosus, all species found in the Thorne samples, as well as in those of Ptilinus pectinicornis and associated with the ant Lasius brunneus. The Sherwood finds were all associated with D. villosus (Carr, 1916). Donisthorpe (1939) also records it from burrows of the longhorn Callidium variabile in a felled chestnut. Palm (1959) again describes this species as an Urwaldrelikt.

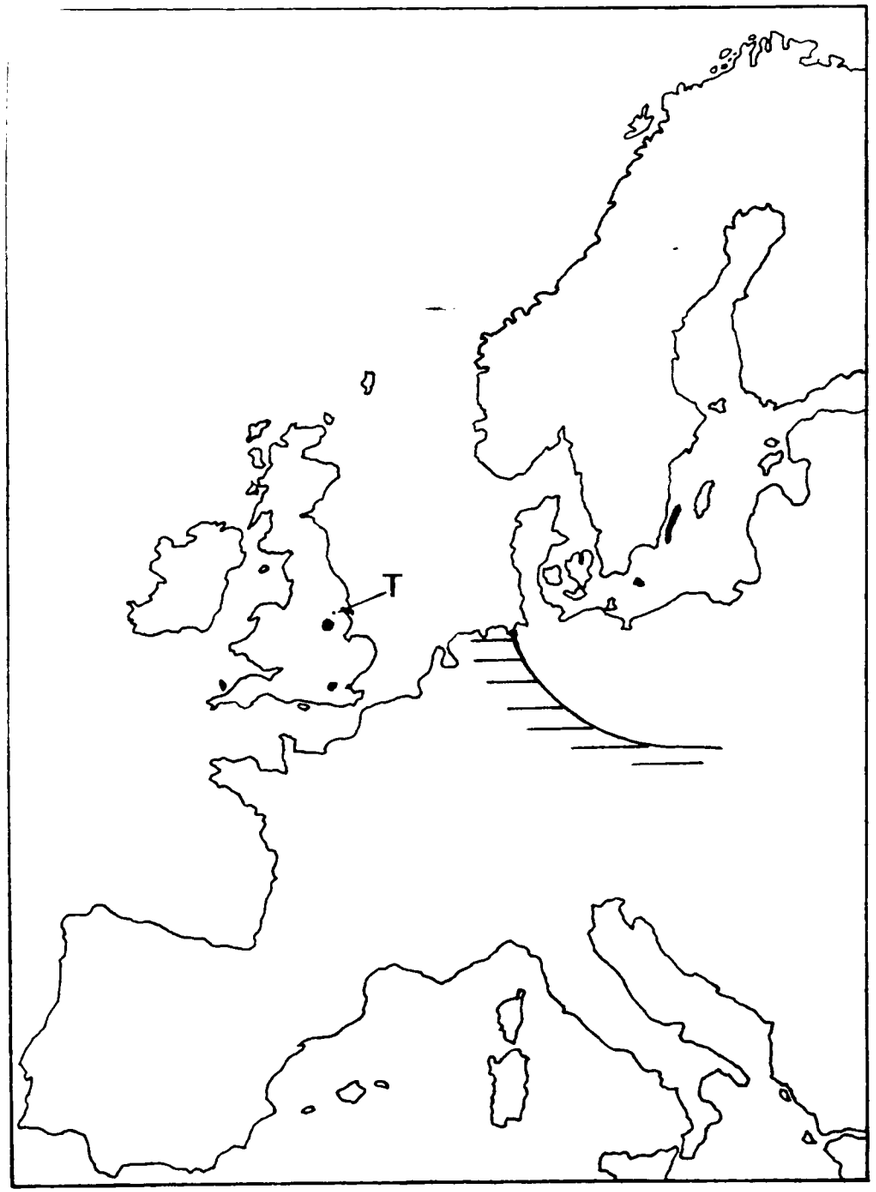

Figure 76. Teredus cylindricus

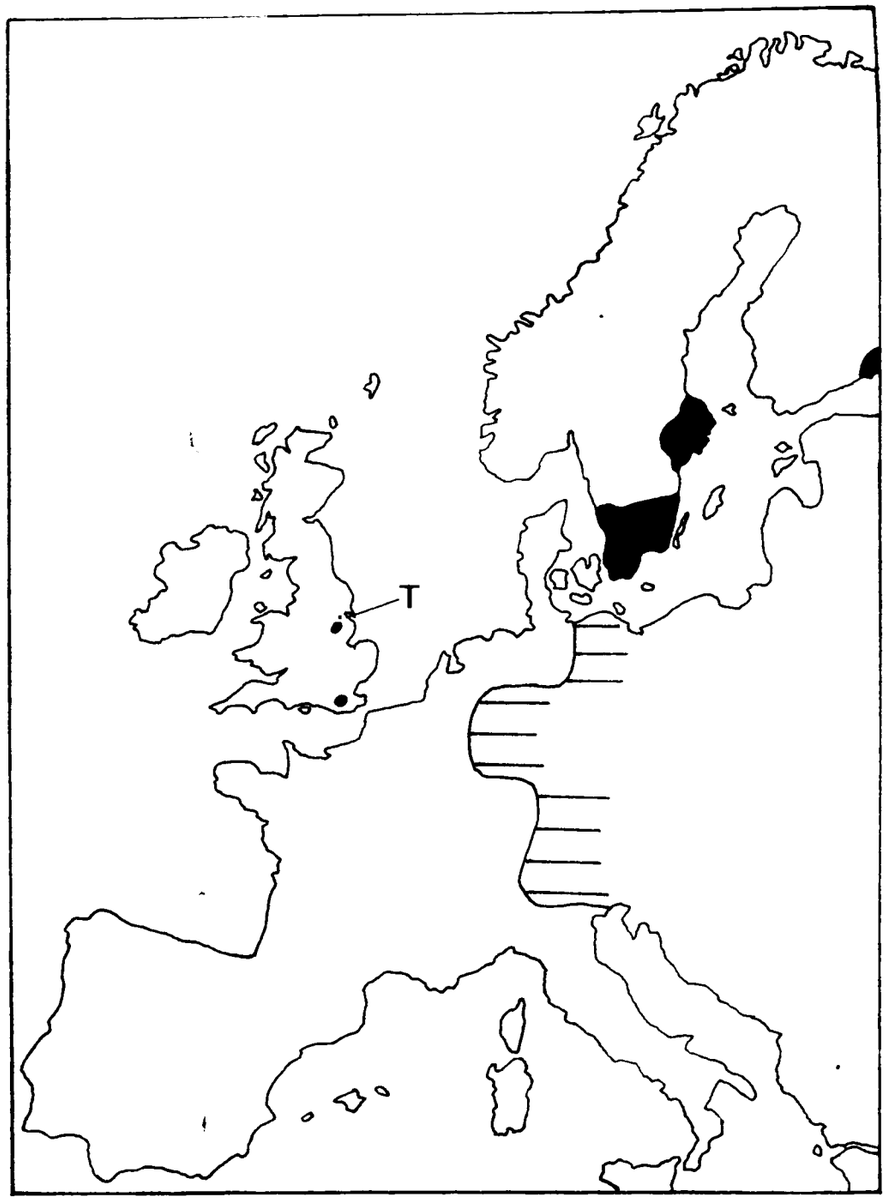

Figure 77. Prionychus melanarius

Anobium denticolle

Distributed as far north as Worcestershire, A.denticolle is very rare in Britain and is recorded from old oaks and hawthorns (Hickin, 1968). The species is absent from Scandinavia and reaches its northern limit on the Danish island of Zealand (Hansen et al., 1960). It is absent from northern Germany and there are only old records for the lower Rhineland (Horion, 1951) and much of eastern Europe (Lohse, 1969). In Central Europe (op. cit.), this Anobiid occurs in most types of deciduous timber and, in winter, under moss on trees and under loose bark. In the western part of its range, it is also known from synanthropic situations, in barns and similar buildings.

Xestobium rufovillosum

The death watch beetle, notorious for its damage to structural timbers in old buildings, is found principally in oak and willow in the open. In Central Europe, it is one of the commonest Anobiids (Lohse, 1969), occurring in wood which has already been subject to fungal attack. In Britain, it is found in the same habitats at least as far north as Oxfordshire, where Fisher (1940) was able to obtain it in large numbers from old willows for his studies on the biology of this species. Northwards, however, outdoor records become progressively rarer and, in Scotland, it is apparently absent from synanthropic habitats also (Hickin, 1968). The insect has rarely been observed to fly in England, although it has fully developed wings and has been taken from flowers in Central Europe (Lohse, 1969). As Fisher (1940) has shown that the species is significantly less active at temperatures below 17°C., the lack of flight records for England probably results from a paucity of

days on which the necessary threshold temperature is attained. The ability of this old forest insect to exploit a man-made habitat can perhaps best be paralleled by such species as Cryptolestes ferrugineus and Aglenus brunneus. Whilst the initial infestation in a building probably came from the utilisation of a piece of infested oak, it should be remembered that, until the eighteenth century at least, most towns and cities in Lowland Britain were almost wholly of timber-framed houses, constructed closely together, usually with ample opportunity for dry and wet rot, and the death watch, driven out of the wild by either human interference and/or climatic change was able to maintain itself in the man-made forests of houses and church roofs in our mediaeval towns. It is, however, certain that few, if any, new infestations now occur and the species is gradually being eradicated from north of its present natural range (Hickin, 1968).

If drastic curtailments in native populations of Xestobium rufovillosum took place in the pre-Roman Iron Age, there are problems of continuity. Towns and cities in Britain and, therefore, the necessary synanthropic habitats, did not exist until the Roman period and, on most sites, there is some doubt as to whether any major buildings in timber or stone and timber survived into the Saxon period. In York, the death watch was established in at least one Anglo-Danish tenement by the tenth century A.D. (Buckland, unpubl.), and present populations - it was present in at least three redundant churches examined in 1973 in the city (Buckland, unpubl.) - probably stem from this and other similar primary infestations. The problem remains, in part confused by the possibilities of imports of infected timbers from areas where the species remained endemic in the wild, as to when infestation from local natural timber became virtually impossible and populations became isolated in largely man-made thermal regimes. Relict populations in the open may have survived until the

early post-mediaeval "Little Ice Age". A late sixteenth or early seventeenth century yeoman's farmhouse examined (1974) at Stockbridge near Arksey, 18 km. south-west of the Thorne site, showed evidence of active death watch in structural timbers and oak panelling, which had been subjected to repeated flood damage and therefore had rotted. This infestation has probably been in the building, probably once a timber-framed house, rebuilt in stone, since its construction but many existing timbers have evidently been reused from an earlier structure and initial introduction from the wild could have taken place at any time during the later mediaeval period. Examination of eighteenth and nineteenth century buildings in South Yorkshire has only revealed evidence of death watch attack where there is obvious reuse of older timbers. There are, however, a number of isolated outdoor records from Yorkshire, from a dry oak stump at Tadcaster (Walsh, 1949) and on an unidentified hardwood lacking bark at Scotton (Walsh, 1953). Until many more sub-fossil records are available this discussion can be carried no further.

Gastrallus immarginatus (Müll.)

In 1936 Donisthorpe and Allen added the species G. laevigatus (Ol.) to the British list from captures made in Windsor Forest. From further captures and re-examination of the specimens in the British Museum, Allen (1954 and 1956) was able to show that the individuals captured in fact belonged to the other continental species of Gastrallus (s. str.), G. immarginatus (Müll.). In Windsor Great Park and Forest, the only British locality, this insect appears to be consistently associated with old trees of the field maple (Acer campestris L.) apparently in dry twigs, although on the Continent there is no such close association. Palm (1959) records it from oak

and lime and Lohse (1969) principally from oak and, more rarely, from other deciduous woods. Unlike the more well known other common tree of the genus Acer, the sycamore, A. pseudoplanatus, introduced in the sixteenth century (Godwin, 1975), the field maple is a native species and may have formed part of the primary forest flora at Thorne. G. immarginatus, under Urwald conditions, however, could easily have been more catholic in its choice of deciduous woods. Allen (1956) suggested that the apparent restriction to a single host tree pointed to the species being relict in the British insect fauna and not a recent introduction, a fact confirmed by the Thorne specimen. Palm (1954) also records this Anobiid from the fry branches of decaying maples in the Strömholm district of Sweden, west of Stockholm, again close to the northern limit of its present distribution, although he does not include this reference in his later discussion of the species (Palm, 1959). It is unfortunate that the Thorne specimen, an elytron and thorax from the Trackway, cannot be associated with any particular tree. The other species of Gastrallus, G. laevigatus is recorded from Central and Southern Europe in mistletoe (Viscum album) and, more rarely, old deciduous trees (Lohse, 1969).

Ptinus fur L.

Although generally a synanthropic species and one of our commonest insects indoors, this omnivorous beetle is also recorded from rotten wood and old birds' nests (Palm, 1959). Northwards it becomes progressively rarer outdoors and is only found in synanthropic habitats in Scotland (Crowson, 1966). As a domestic and stored product pest, it has now become cosmopolitan, although it is now probably less common in Britain than the recently introduced Australasian species P. tectus.

Ptinus palliatus (rufipes Ol.)

In Britain this species is recorded only from the East Sussex coast, Windsor (Allen, 1957) and near Ipswich, Suffolk (Nash, 1972), although it is generally distributed throughout Continental Europe as far north as Central Sweden and is one of the commonest ptinids in the open in Central Europe (Freude, 1969). Unlike the other species in the genus, which feed on animal and vegetable debris, the larvae of this species are active borers, principally in old, dry, fungally rotted wood, usually oak but also recorded from lime, elm, beech, willow, hazel and ivy (Palm, 1959). Both in Sussex and on the Continent P. palliatus has been recorded from old fencing posts. At Windsor the species was found by Allen (1957) in company with another of the rare species on the Thorne list, Teredus cylindrus.

Xylophila oculata / pygmaea and X. brevicornis

It is unfortunate that the pair of species X. (Aderus of recent authors) oculata Panz. and X. pygmaea Deg. cannot be separated on the fossil elytra from the Thorne trackway sample, since Allen (1969) has reaffirmed that X. oculata is the species to be found in England, although the other may occur. Many authors (e.g. Horion, 1956; Hansen et al., 1960) have regarded the two as merely forms of the same species, although Kaszab (1969) lists them as distinct, and it is therefore difficult to derive distributional data. In Britain, X. oculata occurs in most old forest areas, sometimes in numbers (Allen, 1969), as far north as Sherwood (Carr, 1916). It is frequently associated with oak, although Allen (op. cit.) notes that it occurs in any deciduous tree with red-rot and he has taken it from oak, lime, beech, chestnut and hawthorn. Palm's (1959) records from

Sweden were particularly from hollow oaks, where it was associated with Dorcatoma and Anitys spp. X. pygmaea is also largely recorded from oak (Kaszab, 1969) but extends north of the oak zone in Sweden (Palm, 1959).

X. brevicornis is one of the rarest of British Coleoptera with only about a score of recorded captures - from the Weald and Chanctonbury Rings in Sussex, the New Forest and Windsor Forest (Allen, 1969b). Both the Chanctonbury (op. cit.) and one Windsor specimen (Donisthorpe, 1939) were associated with beech, although a later Windsor record is from elm (Allen, 1969). Allen (op. cit.) also notes that this species occurs in Denmark and Sweden, wrongfully equated with X. pentatomus of Thomson. Under this name, Palm (1959) notes the beetle particularly from rotten aspens, although he includes a record from a 'Polyporus' on oak. X. brevicornis is distributed from southern France through Holland (Kaszab, 1969) to Denmark, southern Sweden and, if the synonomy is the same, South Finland (Hansen et al., 1960) but is rare to extremely rare throughout its range, and absent from Central Europe (Horion, 1956).

Phloeotrya vaudoueri

As Allen (1970) has recently reaffirmed, the P. rufipes of British authors is, in fact, P. vaudoueri Muls. of Continental workers. Distributed from southern England north to Yorkshire (Buck, 1954), it was found in Dunham Park, near Altringham, Cheshire, by Johnson (1964) in a small, dead beech branch, nearly one hundred years after the last previous capture in the county; a record from Cusworth Park, Doncaster, is also from beech (Walsh, 1955). It has also been taken in the New Forest (Johnson, 1962), Sherwood (Carr, 1916) and Windsor, where Donisthorpe (1939) found it to be not uncommon under bark and in oak, beech and ash. Buck (1954) also records the

species from hornbeam, although Continental sources (e.g. Horion, 1956) suggest that oak is the preferred host. P. vaudoueri is apparently absent from Scandinavia (Hansen et al., 1961), provided that it is not there confused with P. rufipes, and sporadic and rare in the rest of western and southern Europe (Horion, 1956).

Hypulus quercinus

This distinctively patterned Serropalpid has been recorded from a number of scattered localities in southern England as far north as Huntingdonshire (Buck, 1954). The only record this century was from Devon in 1917 and it was presumed extinct until Allen swept two examples in Darenth Wood, Kent, in 1947. Absent from Finland and only recorded from near Oslo in Norway, the species occurs in Sweden north to about 60°N. (Hansen et al., 1961), in eastern France and the Paris region (Auber, 1960) and in Central Europe it is both sporadic and rare, being restricted to old forest areas (Kaszab, 1969). As its specific name would imply, H. quercinus develops principally in oak, although Buck (1954) also records it from hazel and it appears in chestnut on the Continent (Horion, 1956). The larvae prefer damp wood, either shaded or on the ground, and sometimes occur in decaying roots below the surface. The imagines emerge in late summer, remaining in the pupal chamber to hibernate through the winter (Palm, 1959).

Prionychus melanarius

Johnson (1976) has recently re-examined the British specimens attributed to P. fairmairei Reiche and concluded that all are referable to P. melanarius (Germ.). First recorded in this country in Sherwood Forest by Donisthorpe in 1908, although previously noted as P. ater F. (Carr, 1916), it has also been taken in Arundel

Park, Sussex. In both localities, it is associated with old, rotted oaks (op. cit.), although Buck (1954) merely refers to its habitat as 'under bark'. In Scandinavia and Central Europe, as in England, the species is less common than its congener, P. ater (F.) but is there also found in the decayed wood of other deciduous trees, including beech (Palm, 1959) and conifers (Horion, 1956). Occurring in much of Central and south-east Europe (Horion, 1956), this large Alleculid reaches its northern limit in Uppland, Sweden, and, apart from the English records, is absent further west, an avoidance of Atlantic influence shared with Dasytes niger (above p.239).

Hylophloeus fraxini

In both Britain and Scandinavia, H. fraxini is recorded only from coniferous trees, either under the bark or in Scolytid galleries. Brendell (1975) gives its habitat as under pine bark, usually in the burrows of Ips sexdentatus, more rarely in those of Onthotomicus suturalis or O. laricis. In Central Europe, Kaszab (1969) notes that it occurs most frequently in the galleries of I. sexdentatus and I. typographus, both conifer species, but Horion (1956) also records it from oak, ash and elm. The Thorne association is with oak. The insect, probably a predator on the immature stages of bark beetles (Brendell, 1975), is widely distributed from Central and northern Europe eastwards to Transbaikalia. In Scandinavia, it ranges as far north as northern Lapland, within the Arctic circle, but is absent from Norway and Denmark, apart from the Oslo region (Hansen et al., 1960), avoiding the oceanic regions of northern Europe. It is of rare and very sporadic occurrence in Germany (Kaszab, 1969), being largely restricted to the eastern half of the country (Horion, 1951) and, in England, is only known from west Surrey, east Berkshire, north east Hampshire, west Gloucestershire (Brendell,

1975) and south Staffordshire (Collingwood, 1954); in Wales, the only record is from imported pine in Glamorgan in c. 1923 (Brendell, 1975). It has been suggested that H. fraxini is a recent introduction, imported with pine pit-props from France earlier this century (Hammond, 1974; Brendell, 1975). The specimens from Thorne, which have been confirmed by Brendell, show that the species was endemic three thousand years ago, although subsequent extinction during a colder phase of climate and re-introduction during the amelioration of the first half of this century remains a possibility. Its British distribution, including Windsor Forest (Donisthorpe, 1939) and the Surrey heathlands, remote from both railheads and coalfields, however, suggests that, like several other species, including Ostoma ferrugineum and Simplocaria maculosa (Hammond, 1974), it has been overlooked and belongs to the Urwaldrelikt group. There remains the problem of continuity of suitable habitats, a factor which influenced Allen (1963) into regarding it as an introduction. Although the most southerly macrofossil evidence during pollen zone VIII comes from the East Anglian Fens, there is good palynological evidence for the continued presence of pine in the Hampshire Basin but it is less probable that it survived in Windsor through to the present day, although continuity on the Surrey heaths and the Weald (Godwin, 1975(b)) is possible. H. fraxini would appear to belong to the same ecological group as Gastrallus immarginatus and Eremotes ater, which become increasingly more host-specific towards the limits of their distribution. If the limiting factor in the present distribution of this Tenebrionid was the climatic deterioration of the post-Mediaeval period, then it may have been more catholic in the trees in which it would breed until this period, which is sufficiently late for introduced pines to have been planted and to have matured in the Royal Parks, wherein it could have survived the 'Little Ice Age'.

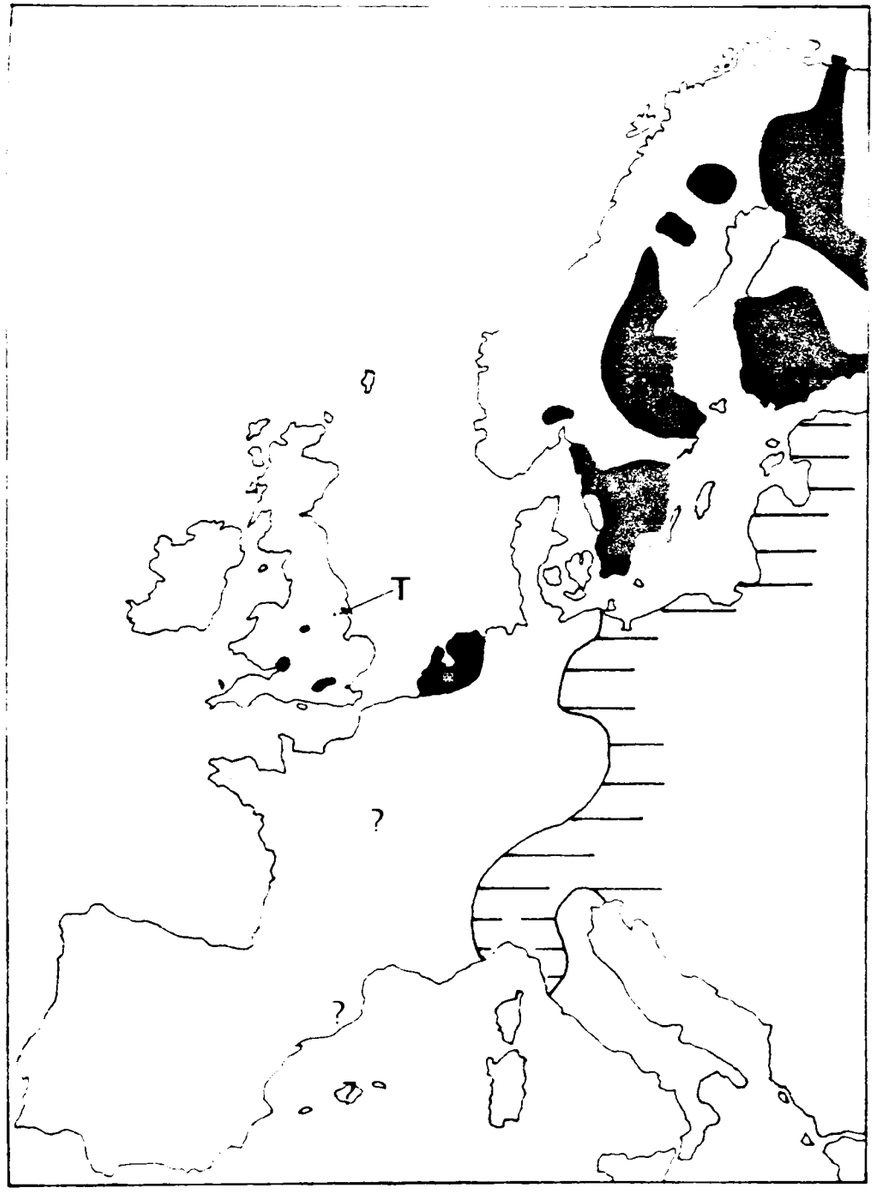

Figure 78. Hypophloeus fraxini

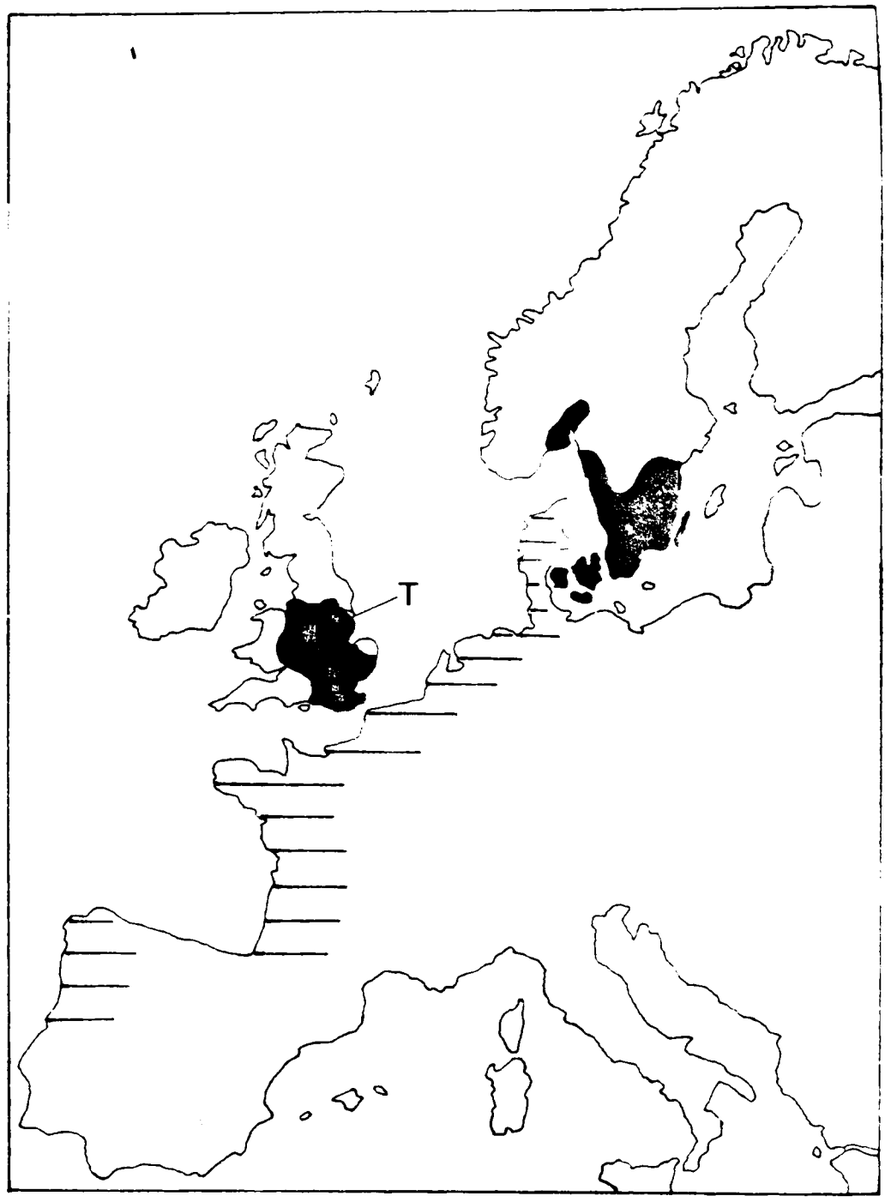

Figure 79. Hypophloeus unicolor

Hylophloeus bicolor and H. unicolor

In considering the current distribution of H. fraxini, it is necessary to provide some background information on its two congeners in the Thorne assemblage, H. bicolor and H. unicolor. The former is fairly common and widespread in England as far north as Yorkshire (Brendell, 1975), occurring, probably as a commensal rather than a predator, with Scolytids (Beaver, 1966). In Scandinavia, it is less widespread than H. fraxini, if more common, and is not recorded from the northern part of Finland. It is absent from Denmark and most of Norway but, surprisingly, it has been recorded from the strongly oceanic, mountainous area of Nordland (Hansen et al., 1961), although this record may relate to one of the more rain-shadowed and continental valleys. In the northern part of its range it occurs in birch, in the galleries of Scolytus ratzeburgi (Palm, 1951) but, further south, it is frequently taken with S. scolytus under elm bark, as well as in bracket fungi (Brendell, 1975) and other deciduous trees (Kaszab, 1969). The Thorne record, with Dryocoetes villosus on oak, is paralleled by Donisthorpe's similar record (1939) from Windsor Forest.

Both H. bicolor and H. unicolor are regarded as sporadic in occurrence and uncommon in Central Europe (Kaszab, 1969) but the distribution of the latter is far more restricted in Scandinavia than either of the other species of Tenebrionid from Thorne, occurring in the Oslo region, Denmark and the southerly provinces of Sweden, north to Östergotland. In England, H. unicolor occurs as far north as Skipwith Common, 20 km. north of Thorne Moors (Aubrook, 1967), and has been taken from beneath birch bark on Thorne Moors (Skidmore, 1970) and from a similar situation in the remnants of Bawtry Forest, the northern tip of Sherwood (Skidmore, 1966). In this country it has also been recorded from beneath the rotting bark of beech and

oak (Brendell, 1975). Swedish records are largely from beech and also, rarely, from birch and bracket fungi, the beetle perhaps being polyphagous rather than predatory (Palm, 1959). Further south in Europe it has been found on other deciduous trees (Kaszab, 1969) and, in Carinthia, Slavonia and southern Italy, the species is also known from conifers; it thus shows increased catholicity with increasingly favourable environment.

Leptura scutellata

This longhorn is closely associated with the remnants of older woodland in England, in which it may be locally common, and is restricted to Windsor, Epping, Hainault, Sherwood (Kaufmann, 1948) and the New Forest (Johnson, 1962); in view of the almost total disafforestation of Ireland, it is surprising to note that there is also a record from northern Galway (Kaufmann, 1948). Adults have been swept from flowers of brambles, hawthorn and Oenanthe, but the larvae have been recorded principally from beech and birch (Donisthorpe, 1939) and also from hornbeam and oak (Duffy, 1953). In Sweden, the species is much more restricted in its choice of suitable timber and has only been found in areas of old, undisturbed beech forest where it occurs in dry, dead beechwood of various sizes, sometimes on still living trees (Palm, 1959). In Scandinavia, it is a rare beetle, recorded only from the four most southerly provinces of Sweden and from Denmark (Hansen et al., 1961); it is more common and widely distributed in Central Europe (Horion, 1951). If the records of pabulae are regarded as complete, the species displays a relationship which is contrary to that of the majority of species discussed; Allen (1956) suggested that, as a general rule, a species became more host specific towards the limits of its range. L. scutellata would appear to follow this in Sweden but is more catholic in Britain.

This could be interpreted to imply that the species shows a preference for a more oceanic climatic regime, yet it is also less stenotopic in Central Europe (Palm, 1959).

Mesosa nebulosa

This fairly large longhorn is now restricted in Britain to south of the Wash (Kaufmann, 1948), principally the New Forest, but with modern records also from Surrey, (Duffy, 1953), Windsor Forest (Donisthorpe, 1939) and Kent (Massee, 1958). In Scandinavia it is present in Denmark but absent from Norway and Finland and in Sweden is restricted to south of the 59°N. line of latitude (Hansen et al., 1961). There are records from most species of deciduous tree, including oak, chestnut, willow, poplar, alder, beech, lime, hornbeam, hazel, birch, apple, holly (Duffy, 1953) and buckthorn (Palm, 1959) yet, despite this apparent catholicity, the preferred host is undoubtedly oak. Donisthorpe took the adults by beating hawthorn trees at Windsor (1939). Oviposition takes place both on the higher branches of moribund or recently dead trees (Duffy, 1953) and in trunks and branches on the forest floor, in trees still retaining the bark (Palm, 1959). The larvae, after developing in the sapwood, pupate in the outer part of it during July and August and the imagines overwinter in the pupal chambers (op. cit.), a development factor which makes them particularly prone to premature activity in relatively warm oceanic winters.

Plagiodera versicolora

Since the hosts of this Chrysomelid are various species of willow, notably Salix fragilis L. (Auber, 1960), the crack willow, which is widespread beside rivers in lowland Britain, it is difficult to account for its present restriction to south of Worcestershire

(Joy, 1932) in terms other than climatic. In Scandinavia, it avoids the more oceanic west coastal provinces of Norway, being restricted to the Oslo region, but further east it is generally distributed in Sweden and Finland, ranging northwards into the taiga and tundra in Lapland and eastern Finmark (Hansen et al., 1960), implying a preference for a more continental rather than merely a warmer regime. The larvae develop on the leaves of the willows and, in France, Auber (1960) notes that two to three generations a year may appear under particularly favourable conditions.

Dryophthorus corticalis Payk.

This weevil was added to the British faunal list as recently as 1925 when Donisthorpe (1939) found several examples in damp wood inside an old oak tree infested with the ant Lasius brunneus in Windsor Forest, Berkshire. Although there are now many individuals from the Forest, largely from oaks in the same condition, this remains the only British locality. On the Continent, the species occurs throughout France, being more common in the Midi, and has been recorded from pine, willow, oak and ivy (Hoffman, 1954). In Fennoscandia, it ranges as far north as Lat. 62°N. but avoids the mountainous areas and the west and south coasts of Norway with their more oceanic climates. It would appear to be attracted to the timber of any dead tree, provided that it has reached a suitable moist but still firm state of decay, a condition which is also preferred by the ants; the weevil is therefore not strictly a myrmecophile (Donisthorpe, 1927). As well as examples from Piilonsuo, Finland (Koponen & Nuorteva, 1973), fossil specimens are known from Shustoke, Warwickshire (4830 ± 100 B.P. (N.P.L. 39)) (Kelly & Osborne, 1965) and two other sites in the Midlands which fall within pollen zone VII, Alcester, Warwickshire (Osborne, 1964) and Church Stretton, Shropshire

(Osborne, 1972). The single Thorne specimen was associated with the decayed oak of tree 1.

Eremotes ater L.

Unlike the majority of the species with restricted distributions here discussed, E. ater belongs to a group previously noted by Osborne (1972; Kelly & Osborne, 1965), which has retreated northwards with the pine forests. It has recently been able to expand southwards with the massive expansion of available conifer habitat created by the Forestry Commission, although up to 1972 there were only two Yorkshire records (Aubrook, 1972) and populations must stem from accidental transport by man. In the face of many cases of southward retraction in this fauna, it is unlikely that this wood-boring weevil's withdrawal to north of the Forth-Clyde line can be explained in simple climatic terms and, although there is good evidence locally for the persistence of native pinewoods in such areas as the Breckland and the Weald (Godwin, 1975), it would seem probable that the effects of man, felling and dispersal of habitat, were decisive factors in limiting its distribution. If we accept uncritically De la Pryme's statement that 'the last standing pines, remnants of the great old forest which once covered the whole Humberhead Levels, sank into the morass' in the late sixteenth century, as Rogers and Bellamy (1972) do, suitable habitats for this insect remained locally until the Little Ice Age. Records from Sherwood Forest (Carr, 1916) might imply continuity of suitable pine habitat, although it has to be remembered that landscape and planting of alien trees began early around the group of large country houses in the Dukeries.

The available ecological data on this beetle from the Continent, however, shows the situation to be far more complex.

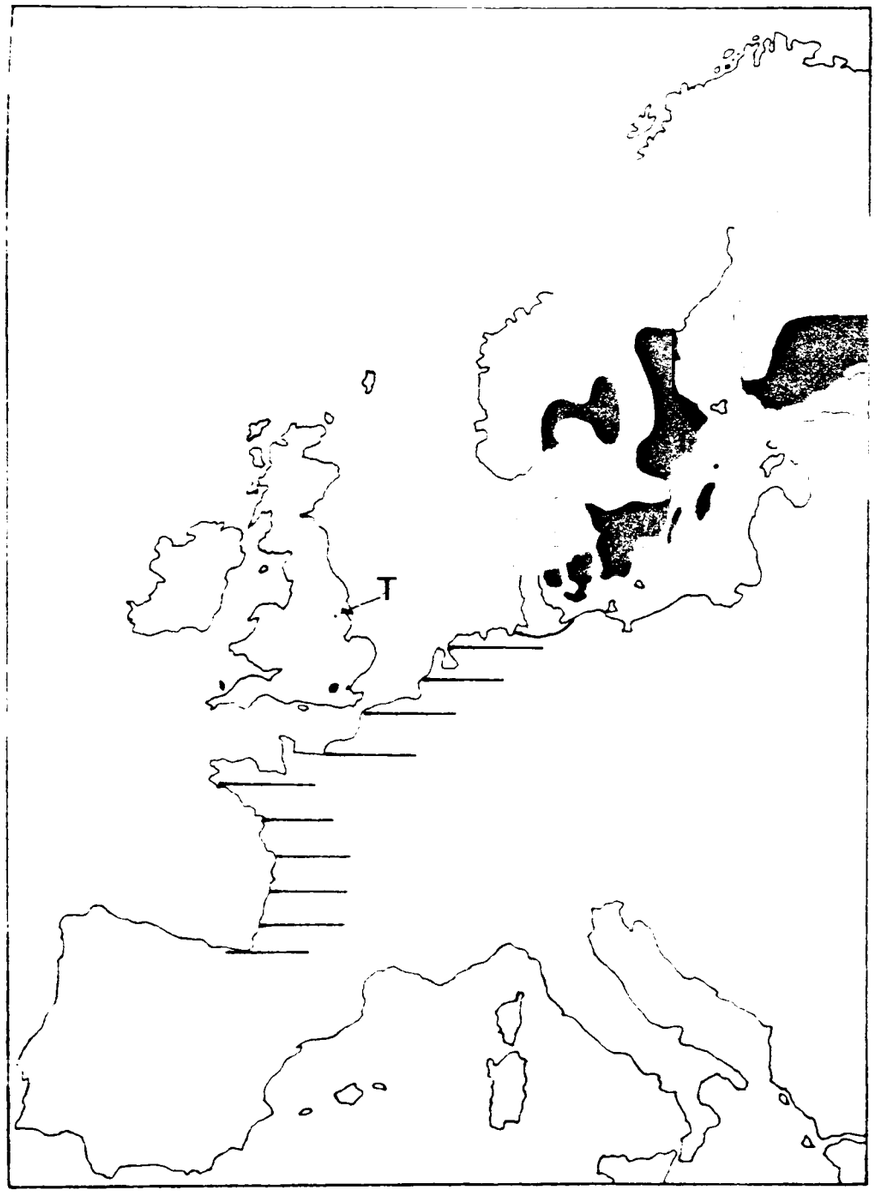

Figure 80. Dryophthorus corticalis

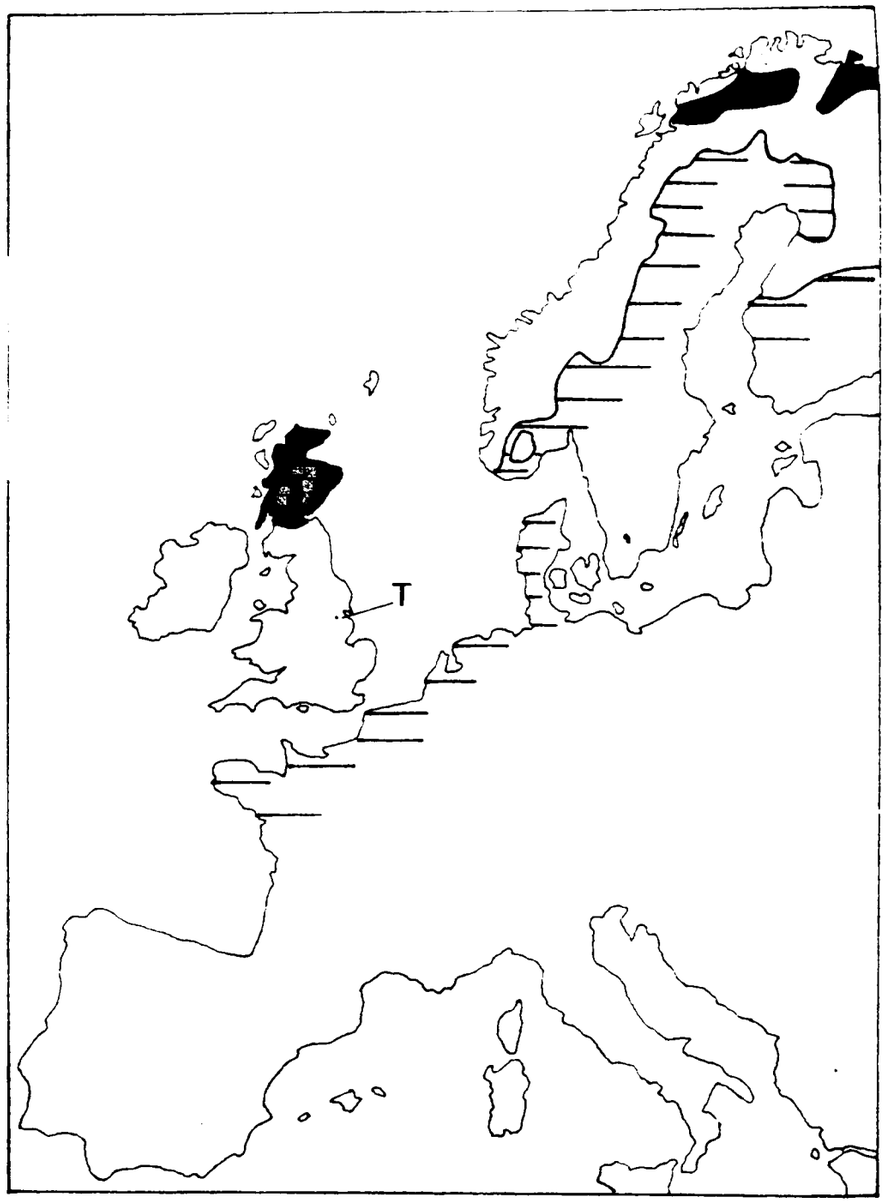

Figure 81. Scolytus ratzeburgi

Although conifers are preferred (Palm, 1951), it is almost as frequent in deciduous woods, particularly birch, but also in oak, beech, chestnut and cork-oak (Hoffman, 1954). In the north of Europe it has also been recorded from the timbers of old buildings (Koponen & Nuorteva, 1973), a situation occasionally met with in this country (Hickin, 1968). It is difficult to invoke Allen's point about increased host specificity towards the limit of a species' range, as has been suggested for some of the insects discussed (above, p. 249), particularly since some of the Thorne specimens are closely associated with an oak tree, unless the deterioration which led to its restriction to pine in the north of Scotland took place after c. 3,000 B.P. and the disruption of more southerly habitats was a subsequent phenomenon. Fossil evidence shows that at some time within pollen zone VII(b) Eremotes ater extended at least as far south and west as Church Stretton in Shropshire (Osborne, 1972). One possibility which can be entertained is the existence of two overlapping clines of the same species, one southern and more catholic, the other northern and tied to pinewood. This hypothesis gains a little credibility in Britain from Godwin's (1975) contention of a separate origin for the Caledonian pine forests, the Thorne Eremotes ater belonging to a southern race which has since become extinct in this country; the confusion of two almost identical species is also a possible explanation. Interpretation, however, must take account of the several other species which have withdrawn northwards (p. 295).

Scolytus Ratzeburgi

S. Ratzeburgi is one species in the Thorne Moors assemblage whose present distribution is difficult to provide any explanation for, since it lives exclusively on the bark and sapwood of one of our commonest trees, the birch. The species was first described

from specimens collected at Rannoch in Perthshire in 1856 and has subsequently been taken at several scattered localities, largely in the Highlands, the most southerly being near Hawick in Peebleshire (Carlisle & Crooke, 1951). This bark beetle might appear to prefer an oceanic climatic regime, particularly since it occurs around Fort William (Skidmore, pers. comm.), which, as Poore and McVean (1957) show in their vegetational survey, is one of the most oceanic parts of Scotland. The Scandinavian evidence, however, clearly contradicts this proposition since it is not recorded from any of the more oceanic coastal provinces of Norway but is present throughout most of Sweden, Finland and Denmark, except the tundra in the far north (Hansen et al., 1961). Southwards, it is widespread but sporadic in occurrence in Central Europe and extends eastwards through the Caucasus and Siberia to Japan (Horion, 1951). In Sweden, the species is sufficiently common to be a major pest of birch, although it only attacks trees which have been damaged in some way, either by leaf-feeding lepidoptera, by fire or physical injury (Palm, 1959). Solitary trees left for seeding a cleared area within the forest after felling are also attacked and, occasionally, felled birches left lying on the forest floor (Palm, 1951). That the beetle assumes pest proportions in the Baltic region and is somewhat rare in Scotland - after the initial captures, it was not taken again until 1923 at Hawick (Carlisle & Crooke, 1951) - would imply that the latter is the more marginal population, perhaps of relict status. The absence of a correlation between distribution and winter isotherms is matched by a similar disparity with summer temperatures suggesting that the insect is eurythermal; its absence from England, however, has to be explained. It has to be accepted that detailed knowledge of the physiological requirements of all the species discussed is slight and some factors with which we are wholly unfamiliar may be involved.

S. Ratzeburgi is not restricted to pure stands of birch, occurring in mixed birch and conifer forests in northern Sweden (Palm, 1951) but it seems significant that, in Scotland, the natural climax vegetation for much of the higher parts of the glens, from which it has been recorded, would be birch forest (McVean, 1964) and this tree has formed an important element in all the forest regions of Scotland through from the end of the last glaciation (Godwin, 1975). S. Ratzeburgi appears to show a predilection for old established birch forests with a minimum of human disturbance, rather than mixed, secondary deciduous woodland. Although the frequency of birch in pollen diagrams covering zone VIII in eastern England is far less than in Scotland, by the Middle Bronze Age when the Thorne specimen shows S. Ratzeburgi to be endemic at least as far south as the Vale of York, birch scrub would again have been on the increase as a factor in forest regeneration after clearance. In the absence of accountable natural parameters governing this beetle's distribution, one is thrown back upon the possible anthropogenic influences and the differing patterns of forest and woodland exploitation between the Highlands and the rest of Britain. There can be little doubt that the chances of extensive stands of birch reaching maturity and senescence in the Lowlands would have been less than on the less densely populated Uplands. Grazing pressures in the Scottish Highlands only became important with the eighteenth and nineteenth century Clearances in favour of sheep; in the remainder of Britain grazing would have reduced regeneration and, as a tree with little value as timber, birch wood would have been extensively utilised as firewood. The frequency of mature birch woods in much of Britain by the early post-mediaeval period was probably relatively low and available habitats for the birch bark beetle relatively dispersed. Its absence from Ireland may be the result of the almost total deforestation, completed

by the late seventeenth century (Smith, 1975); in Britain, continual habitat disturbance and dispersal may have been the most important factor. Only on the least accessible mountain sides in the Highlands has S. ratzeburgi found sufficient continuity of habitat to survive. If this is the explanation for its curious disjunct distribution, it does not explain the record from near Hawick. The pattern is also followed by a moth, Zygaena achillae Esp., which is widespread in Europe from the Mediterranean littoral to Central Europe, is absent from England and Lowland Scotland and reoccurs in the Highlands and Islands (Crewdson, 1962). As the more obvious case of the pine weevil E. ater, human interference in the habitat appears the most acceptable hypothesis, yet climatic and historic factors, like the Carse Clay transgression which virtually divided Scotland during Zone VII(a) along the Forth-Clyde line (Godwin, 1975) may require consideration when more fossil evidence is available. It is also salutory to remember that the Rannoch rush, Scheuchzeria palustris, has, within the last one hundred years, assumed a rather similar, if more restricted, distribution to S. ratzeburgi, as a result of the activities of man (Godwin, 1975).

Platypus cylindrus

The only Platypodid currently on the British list, P. cylindrus occurred in small numbers both in the Trackway samples and Tree 1 at Thorne. At the present day, it is found locally as far north as Cheshire (Joy, 1932) and Yorkshire, where it is recorded from the Scarborough district (Walsh, 1956). One of Palm's (1959) Urwaldrelikt species in Scandinavia, it is restricted to the south-eastern corner province of Sweden, Blekinge, where it was recorded in the nineteenth century and again in the 1950's, occasionally locally in large numbers. It has also been introduced, presumably in

imported oak, to the Danish island of Zealand (Hansen et al., 1960). In Central Europe, it is sufficiently common to be a pest on oaks, boring into the sap-rich base of the trunk in both felled and standing trees, cutting through to the heartwood and the larvae feeding off Ambrosia fungi, which line the galleries. The species is also recorded, less frequently, from beech, ash, elm and sweet chestnut (Hickin, 1968). In Windsor Forest, Donisthorpe (1939) noted it under the bark of both oak and beech, locally very abundant, and examples were noted flying, crawling over and burrowing in freshly felled trees. Chrystal (1937) suggests that this pinhole borer had become a forestry pest during the previous few years in the south and west of England and it is tempting to relate this apparent resurgence to the climatic amelioration which culminated in the 'thirties (Lamb, 1969). Hickin (1968) regards it of minor importance as a forestry animal since attacks usually occurred in stumps; whether there has been a decline in its abundance over the past forty years cannot be culled from the available data.

Whilst many of the species with a limited southern distribution tend to be south-eastern, P. cylindrus occurs from Kent to the New Forest, Oxfordshire and the Forest of Dean (Hickin, 1968) and, whilst the latter lies to some extent in the rain shadow area of the Brecons, Skidmore and Johnson's (1969) specimens from old oaks near Dolgellau are from a thoroughly oceanic part of Merionethshire. These records rather negate the impression gained from the very restricted Swedish and the German (Horion, 1951) distribution of a species with a strong preference for a more continental climatic regime.

Xiphydria prolongata

As Skidmore (1966) has noted, this large sawfly has been taken from old willows alongside the River Dearne on Denaby Ings, 20 km. west of Thorne Moors. It is largely confined to south of a line from the Wash to the New Forest, with outliers in Herefordshire and Nottinghamshire. On the Continent the larvae are also recorded from poplar and elm wood (Benson, 1951). Its congener, X. camelus, a single specimen of which was also recovered from timber from Thorne, has a more widespread, if local, British distribution and is recorded from alder and birch (op. cit.).

Species no longer recorded from Britain from other post-Glacial sites

Oodes gracilis Villa

As the only Carabid not currently recorded in Britain to have been published from Flandrian deposits, Girling's (1976) find of O. gracilis from peat of pollen zone VII(b) age in the Somerset Levels requires comment. Apart from a limited area near Stockholm, this beetle is today restricted to south of the 55°N. line of latitude and in Germany Horion (1951) was only able to note the species from Thuringia, Brandenburg, Prussia and Silesia. Lindroth (1945) records it from around Lake Mälar in Sweden as living exclusively by stagnant eutrophic waters, with rich fen vegetation, walking on the surface of the gyttja substrate. O. gracilis appears to be strongly thermophilous and the Swedish population could be regarded as a relict from a warmer period surviving in a sheltered locality. The widespread disruption and destruction of its very particular habitat, however, caused by the drainage of fen and marsh, may have been equally deleterious. The wings of O. gracilis are well developed and, as a good flier, it should be able to move to suitable habitats within its thermal range. It is therefore difficult to escape Lindroth's (1943; 1945) contention that the insect requires a fairly high, stable temperature in summer and that this is the controlling factor in its distribution. It would be interesting to know whether it survived in the abundant fenland habitats of eastern England until the seventeenth century drainage and 'Little Ice Age' jointly destroyed its niche or whether it fell victim to some earlier climatic vicissitude.

Agabus wasastjernae Sahl.

The extensive reclamation of lowland fens has resulted in the drastic retraction in range and probable extinction of some

species of water beetle (Hammond, 1974). A. wasastjernae, however, which Osborne (1972) obtained from sediments of pollen zone VII(b) at Worldsend, Shropshire, is a northern species of acid pools and marshy areas in coniferous woodland and its disappearance may be a feature of the disruption and destruction of that habitat, although, if causes are wholly anthropogenic, absence from the Caledonian pine forests is surprising. In Scandinavia, however, this Dytiscid is predominantly eastern, occurring in most of Finland and Lapland and the central mountain chain of Sweden and Norway; it avoids the oceanic coastal provinces of Norway (Hansen et al., 1960). In isolation, it would seem to imply a more continental climate during zone VII(b) but several other species, including Scolytus ratzeburgi from Thorne (above, p. 263), have contradictory British and Continental distributions and a combination of factors, including historical accident, may be involved.

Porthmidius austriacus Sch. (fig. 84)

This Elaterid, recovered by Osborne (1972) from deposits of pollen zone VII(b) at Worldsend, near Church Stretton, Shropshire, has not been found in Scandinavia and is restricted to South East and Central Europe, ranging north as far as Belgium, with a discontinuous distribution through Germany, and occurring eastwards as far as Anatolia (Horion, 1953). A rare species, Horion (op. cit.) regards it as a particularly thermophilous element in the German fauna. It is assumed to live in rotten wood (Reitter, 1911) but Horion (1953) says that the larva is unknown and, whilst including alleged records from honeysuckle, notes that imagines have been taken in flight or on flowering shrubs at the edge of woods, particularly on hot sunny days. The paucity of habitat data aids a simple interpretation in terms of climatic parameters but, without further information, it is of little value.

Airaphilus elongatus (Gyll.)

Osborne's (1974) record of this rare continental European Cucujid from a fourth century well at Droitwich, Worcestershire, provides something of a caveat on the premise that forest and other habitat destruction by man have been the principal factors in the depletion of the British fauna, since it is a species of marshy meadows (Vogt, 1967), rotting grass and haycocks (Horion, 1960). Since the specimens come from a man-made feature, accidental importation is, as Osborne notes (op. cit.), a possibility, perhaps in hay or straw used as dunnage or packaging for fragile items within the Roman period, followed by the temporary establishment of a small population in a particularly favourable locality. This explanation seems singularly attractive in the light of evidence for accidental transport of many other species (e.g. Lindroth, 1957; below, p.), but it is curious that a breeding community of this one completely unsynanthropic species should survive the transhipments necessary to get any object to the very land-locked site of Droitwich. Several Late Glacial records of this insect are known (Osborne, 1972; Coope & Brophy, 1972) and an Interglacial one from Bobbitshole, Ipswich (Coope, 1974). Osborne favours the suggestion that it may have been native during the Flandrian and become extinct in the post-Roman period or that it is still native and has been overlooked. The latter gains some support from the continued addition of species to the British list (Hammond, 1974) and the one example of A. elongatus from Belgium, which was not collected until 1946 (Horion, 1960).

Pycnomerus [illegible] Ol.

Osborne (1972) recorded this Colydiid from a site of pollen zone VII(b) age at Kinsterly, 20 km. north of Church Stretton,

Shropshire. It is absent from Scandinavia and largely eastern and southern in Europe, occurring in old oaks (Ganglbauer, 1899), alders and with the ant Lasius brunneus (de Buysson, 1912). Although the latter association may be, as that of Dryophthorus corticalis (above, p.260), somewhat fortuitous, Vogt (1967) also associates the beetle with this ant in old, rotted deciduous wood. It is interesting to note that an Australasian member of this genus, P. fuliginosus has managed to establish itself in this country, having been introduced with imported timber (Allen, 1968).

Dermestes laniarius Ill.

As a species with a wide distribution in the palearctic, including much of the European mainland (Horion, 1955), it is surprising that this Dermestid has been unable to establish itself in Britain. Many other members of this genus have become cosmopolitan as pests of stored products but, between 1957 and 1969, there was only one record, in a cargo of potatoes from Greece, of D. laniarius reaching this country, compared with over two thousand importations of D. maculatus Deg. and over a thousand of D. ater Deg. (Aitken, 1975). Although Osborne (1969) tended towards regarding the specimens from the Late Bronze Age Wilsford Shaft as casual introductions, perhaps with hides, the species is associated with waste ground with spare vegetation in Rostov, east of the Sea of Azov, in the U.S.S.R., where Minoranskiy (1969) found it to be the most common and widespread Dermestid. Its Scandinavian distribution (Hansen et al., 1960) also shows a strong bias towards regions with a more continental climate, being absent from Norway, apart from the Oslo district, and from the northern parts of Sweden and Finland (fig. 82). It is markedly xerophilous, occurring on the surface of the soil during the hottest part of the day, feeding on dead invertebrates and very small

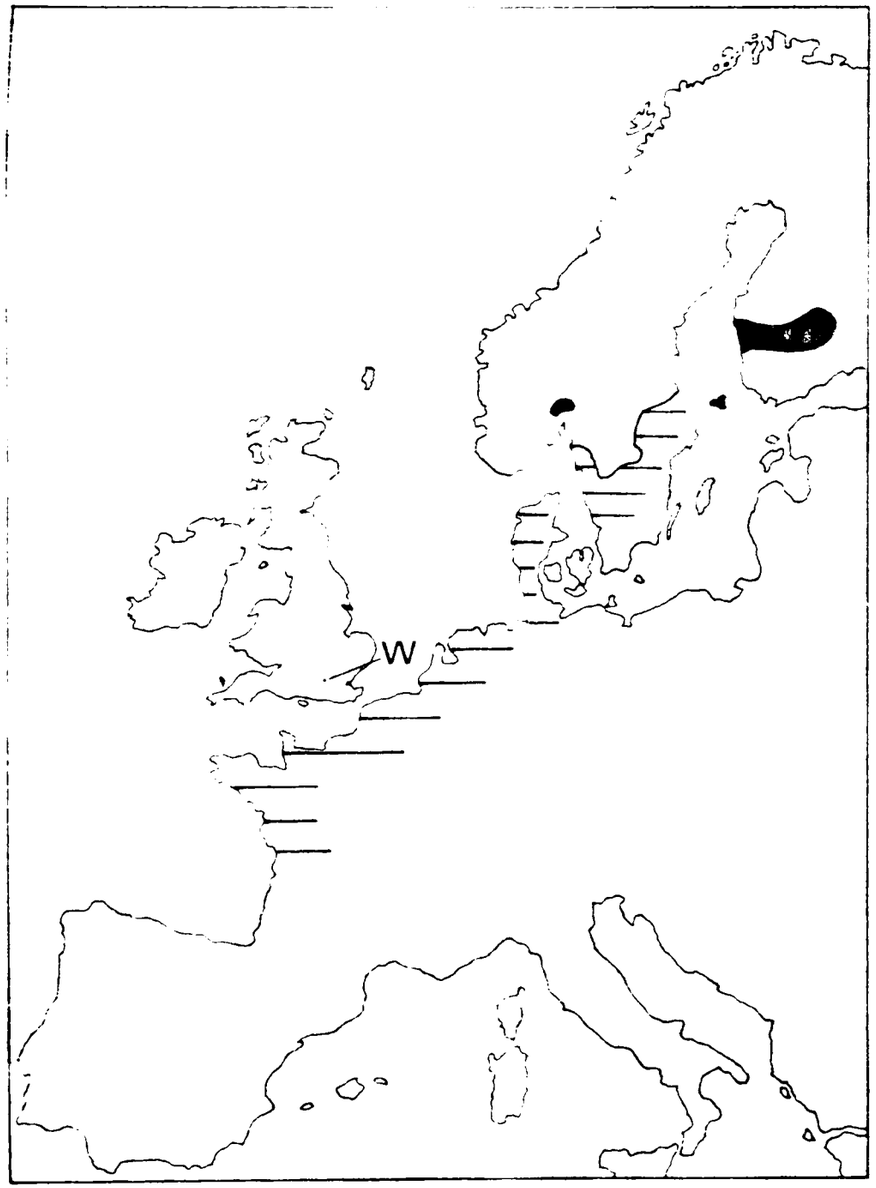

Figure 82. Dermestes laniarius

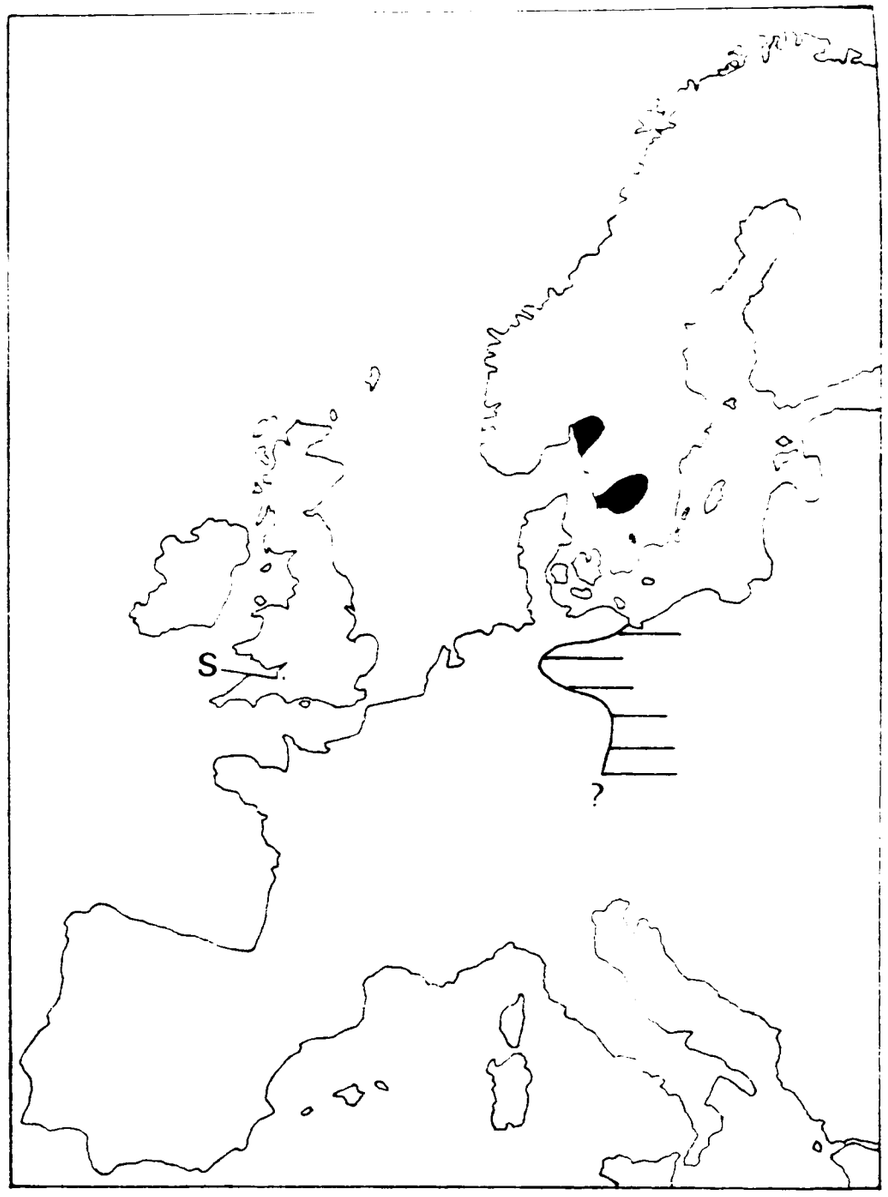

Figure 83. Anthicus gracilis

vertebrates (Minoranskiy, 1969). It is possible that the species in Britain represented a native, open ground element, which enjoyed a brief floruit during the earlier phases of forest clearance and shifting agriculture, succumbing to later changes. Only additional fossil records, away from occupation sites, can clarify its history.

Anthicus gracilis Panz.

Of the many species recorded from fossil assemblages not presently known from Britain, A. gracilis is perhaps the most likely to have been overlooked. In Central Europe, it occurs under rotting plant debris by lakes and river banks (Kaszab, 1969) and is recorded hibernating in stems of Typha sp. (Horion, 1956). Both the Somerset Levels (Girling, 1976) and the Le Havre fossil records (Ters et al., 1970) suggest an association with reed-swamp litter, a habitat which is both difficult to examine and less frequently worked than many others and, as Airaphilus elongatus (Gyll.), it may yet await discovery in this country. The species tends, however, to be rather southern and eastern in Europe, if not rare (Kaszab, 1969). Horion (1951) was only able to provide recent records in Germany for Mecklenburg, Brandenburg and Silesia and the Swedish record from Bohuslän is a solitary old one (Lindroth, 1933). It is recorded from the Oslo region in Norway and, in Finland, from south-east Karelia (Hansen et al., 1960) (fig. 83). The distribution data suggest a preference for a more severely continental climate.

Aphodius quadriguttatus (Host.)

Along with the probably extinct in Britain species of Onthophagus at Wilsford occurred a minimum of five individuals of a Scarabaeid which has not been taken in this country, A. quadriguttatus.

An oligotropic species preferring open pasture, where it has been taken from cow, sheep and horse droppings (Landin, 1961), one is tempted to accept Osborne's (1969) suggestion of a very slight deterioration in climate since the Late Bronze Age, which has pushed it out of England but Horion's (1958) evidence from Continental Europe causes one to be more circumspect. In Germany, A. quadriguttatus was common throughout the country in the nineteenth century but, apart from two isolated localities, which Machatschke (1969) regards as particularly warm, it is now absent from the northern half of the country. It is noted as rare in Latvia in 1891 and there are no subsequent records from the Baltic region, other than from the sandy substrates of eastern Scania (Landin, 1961). In Austria, although not particularly rare in the south-east, there are only old records from Steiermark and Carinthia. In spite of the slight climatic amelioration of the first half of this century (Lamb, 1969), this dung beetle has continued to retract its range on several fronts and this can be seen as part of a process which has resulted in its disappearance from Britain, after the Late Bronze Age and before systematic collecting began. It is difficult to quantify factors other than the thermal regime which could have led to changes in the distribution of a species associated with a frequent, open habitat.

Landin (1961) has carried out extensive studies on the Aphodiini, although unfortunately not on this species, and has shown that the insects show preference for situation and microclimate rather than for the dung of any particular herbivore. The recent decline cannot, therefore, be easily linked with changes in domestic animal foodstuffs, although the possibility of a specific nutrient requirement might be considered. Extremely hot summers have a deleterious effect upon dung beetle populations and breeding is delayed until the milder conditions of autumn pertain (op. cit).

Where winter stalling of domestic stock is or has been extensively practised, the continuity of population rests upon a sufficient supply of droppings from wild animals. Similarly a summer with frequent torrential rains may interfere with propagation by both increasing mortality and dispersal of dung heaps. Although some protection from such vicissitudes can be obtained by a migration towards more shaded habitats, for a species closely associated with open ground close to its distributional limit, as defined by macro-climatic factors, a succession of hot or wet summers in an area with little woodland or game may be sufficient to extinguish the population. The continued decline of A. quadriguttatus, however, may be linked to that shown by other dung beetles in Britain (Johnson, 1962), a victim of pasture improvement on the poorer, sandy soils and increased arable cultivation.

Cerambyx cerdo L.

Whether this large longhorn was native to this country excited the interest of entomologists for over one hundred years (summarised in Duffy, 1969). It became generally accepted that it only occurred as a casual introduction until 1969, when Duffy (op. cit.) received a complete specimen from a bog oak from Isleham, near Ely, Cambridgeshire, an area where Stephens (1839) had recorded the species as indigenous over a century ago, although Allen (1968) notes that Stephen's description is in fact of congener C. scopolii. A ^{14}C assay on the wood gave a date of 4,000 $\pm$ 66 B.P. (Birm. 1) but it is clear that Duffy did not accept the date and regarded the specimen as one of relatively recent origin. It is unlikely that Duffy, the author of a major monograph on the immature stages of Cerambycidae (1953), should have so mistaken the nutritional value of bog oak as to suggest that C. cerdo was capable of developing in it

and it is more probable that he felt that the tree and beetle were only a hundred or so years old and that the ^{14}C date was wholly spurious, the coincidence of the findspot with Westwood's record being, in his opinion, too great for chance. During the preparation of an interim note on the Thorne site (Buckland & Kenward, 1973), Kenward re-examined the Isleham specimen and found no reason for not accepting the contemporaneity between the insect and the wood dated in Birmingham. In view of the dubiousness of the nineteenth century records (Morley, 1943), this longhorn cannot be included on the current British faunal list, although the date of its final disappearance from this country can only be established in terms of a terminus post quem from an adequate fossil record.

In Scandinavia, the Catalogus (Hansen et al., 1960) includes C. cerdo from Skane, Blekinge and Öland but Palm (1959) states that the only known Swedish locality was Halltorp on the island of Öland, where the most recent capture known to him had been in 1956. It is not known from Denmark, where a fossil occurrence has been used to support the hypothesis of a warmer climate during the 'Climatic Optimum' (Thomsen & Krog, 1949; Degerbøl, 1964). In eastern and Southern Europe, however, the beetle can be a serious pest of oak timber, damaging trees in plantations (Palm, 1959). Although Palm (op. cit.) describes the species as an Urwaldrelict, the preferred habitat of rather isolated old oaks implies at least an open canopy rather than closed primary forest. The beetle is also recorded from apple, elm, beech, willow, hornbeam and Robinia and infestation can continue in the same tree for upwards of thirty years (Duffy, 1953). Rudnev's work (1935) on the biology of this longhorn in the Ukraine provides some data which may be relevant to the factors limiting its distribution. He found that fungi infected 73% of the immature adults, 49% of the larvae and 36% of the pupae examined in the field

and that the Hymenopterous parasite Tynandricus rudnevi Nov. accounted for up to 50% of the eggs. In a climatic regime more conducive to entomophagous fungi, the balance could easily be tipped towards extinction.

In view of the apparent morphological stability of insect species over periods in excess of one million years (Matthews, 1974), the claim that the distinctive large galleries, lined with a calcareous secretion, of C. cerdo were recognisable in Tertiary lignites in Germany (Linstow, 1905) is interesting.

Eremotes elongatus Gyll. and E. strangulatus Perris.

Both these species were recorded by Osborne (1972) from deposits of Pollen Zone VII(b) at Worldsend, near Church Stretton, Shropshire. E. elongatus is recorded from a few scattered localities in southern Scandinavia and is more widespread in France and Germany. Whilst old records would suggest that this wood-boring weevil is quite catholic in its choice of host trees, Palm (1953) has shown that most Swedish records are referable to E. nitidipennis and that the principal host of E. elongatus is pine, although, further south, it is also recorded from fir (Hoffman, 1958). Its congener, E. strangulatus, is also a pine species but is much more restricted in its distribution, occurring in central France and Corsica (op. cit.). The disappearance of these weevils from Britain could, at least in part, be related to the radical decline in pine in the Lowlands but thermal factors must be considered since both were unable to maintain populations in the Scottish pinewoods, where several other pine insects, including E. ater (above, p. 261), were able to continue.

Further rare British species from
the Hatfield Levels and North Lincolnshire

Hydrophilus piceus L.

It is unfortunate that the virtually complete specimen of H. piceus, found in the peat on Hatfield Moors early this century and preserved in the Doncaster Museum collections, cannot be dated in any way. Balfour-Browne (1958) has reviewed the evidence for the decline of this species, our largest water beetle, since the first half of the last century, when it seems to have been fairly common around London. The expansion of the suburban sprawl around the Metropolis has destroyed the majority of suitable ponds and marshes but it would appear that Balfour-Browne was being unduly pessimistic when he suggested that resident populations only survived in Somerset and that captures in South-East England stemmed from recruitment from the European mainland. The species has subsequently been shown to be well established in west and mid-Kent (Massee & Southwood, 1962) and in the Sussex marshes (Foster, 1965). H. piceus has been taken in the Norfolk Broads and the Fens but there are few recent records outside Wicken Fen (Balfour-Browne, 1958). Further north, it is referred to from Repton, Derbyshire, in 1863 and from near Huddersfield before 1878 (op. cit.). The filling in of many suitable ponds, drainage and progressive eutrophication of waters has severely affected many species of water beetle, if the Huddersfield examples and the fossil from Hatfield are taken as evidence for H. piceus having once been more widespread, then the decline clearly began before these factors became significant on a more than local scale, although the drainage of the Humberhead Levels and canalisation of its rivers, beginning in the seventeenth century, may have started the process of isolation of populations in the North.

Onthophagus fracticornis (Preyss.)

Osborne (1969) has discussed in some detail the large numbers of individuals of this species recovered from the Late Bronze Age well at Wilsford, Wiltshire. At the present day, O. fracticornis is represented in England by only eight old, unlocalised specimens, although Landin (1959) refers to Irish examples, and its place is taken by O. similis (Scriba), with which it was previously confused (Allen, 1967). Both species seem to be relatively eurytopic, occurring in all types of herbivore dung on any soil, often in the same droppings. The species are, perhaps, to some extent sympatric in their distribution in Europe and Horion (1958) produces some evidence to suggest that O. fracticornis is the more thermophilous of the pair. In contrast to the considerable dominance of this latter species at Wilsford, Osborne (1972) recovered a single example of each from deposits of Zone VII (b) at Church Stretton, Shropshire.

Onthophagus nutans (F.) (verticicornis (Laich.))

Osborne (1969) recovered seven individuals of O. nutans amongst the extensive fauna of dung beetles from the Late Bronze Age well at Wilsford. In Britain it is presently regarded as extinct, with records last century from the London region, where Stephens (1830) notes it as very common, Bath and Swansea; there is a solitary record from the north of England, from Armathwaite in Westmorland (Allen, 1965). During this century, this species has only been taken once, in Dorset in the 1920's (op. cit.). O. nutans is found from south and central Europe eastwards through Syria and the Caucasus to Turkestan but is absent from Scandinavia and the North German Plain (Horion, 1951). Its apparent decline in England is paralleled in Germany, where there are only old records from much of

the south and west (op. cit.). Although the Wilsford fauna (Osborne, 1969) is indicative of open grassland on the Chalk, in Central Europe, O. nutans occurs in woodland, hilly and low mountain areas (Machatschke, 1969)

Aphodius arenarius (Ol.)

Although Joy (1932) only records this species as far north as Cambridgeshire, the insect fauna of the contiguous county of Lincolnshire is relatively poorly known and it may have been overlooked. As its specific name implies, A. arenarius is usually associated with sandy areas and is recorded from dung in pasture on open, sandy ground (Landin, 1961). Such pasture has been increasingly subjected to improvement and turned over to arable during the last one hundred years and the disappearance of this dung beetle from North Lincolnshire since the end of the Bronze Age, when it is recorded from beneath the Brigg boat (Buckland, in press), may be a relatively recent phenomenon. The insect, however, would appear to be rather specific in its temperature requirements, being restricted to the southern provinces of Sweden (Landin, 1961) and, in France, occurring throughout north of the Loire but becoming montane in the Midi (Paulian, 1959). Osborne's (1969) fossil records from a site on the Wiltshire Chalk could imply that it is more eurytopic than the relatively few records suggest, perhaps in a slightly warmer thermal regime, and, in France, it prefers dry ground and is found in plant debris as well as sheep dung (Paulian, 1959). Its probable retraction to south of Lincolnshire may have a climatic parameter and the recent fragmentation and disturbance of suitable habitats, which were widespread until the decline of extensive sheep pasturage on the Cover Sands outcrop, may have precluded successful re-immigration, although Johnson (1963) notes that the species is very rarely taken in southern England at the present day.

Gnorimus variabilis L. (octopunctatus F.)

Although the faunas from beneath the Late Bronze to Early Iron Age boat from Brigg, north Lincolnshire, show largely a Phragmites reed-swamp adjoining pasture, the insect lists do include a few indicators of old woodland (Buckland, in press). The large chafer Gnorimus variabilis is now restricted in Britain to Windsor Forest where it has been taken at infrequent intervals since c. 1830, locally in some numbers in all stages of development in the loose, damp wood-mould in the forks of old oaks (Donisthorpe, 1939). In Scandinavia, the larvae are also recorded from fallen oaks and, less commonly, from hornbeam (Palm, 1959) and French records add alder, chestnut, beech and pine to the list of hosts (Paulian, 1959). Locally common but nevertheless a rare beetle, it reaches its northern limit in southern Sweden and Denmark (Hansen et al., 1960) and remains an uncommon insect throughout continental Europe; it was last taken in Denmark in 1915 (Johnson & Krog, 1948) and is probably now extinct there. The adult is an active flier and its presence in the Brigg assemblage need not be entirely fortuitous since it is recorded from flowers, including meadowsweet (Filipendula ulmaria) (Palm, 1959), a plant which could have grown in the wetlands of this site.

Gnorimus nobilis L.

During fieldwork with the author in 1970, Mr. P. Skidmore of Doncaster Museum found fragments of this distinctive green chafer in a rot-hole in an old oak from the base of the peat on Norton Common, near Askern, 12 km. north of Doncaster (Skidmore, 1971). By analogy with the Thorne Moor succession the author, probably unwisely, suggested a similar Late Bronze Age date. Although this locality lies only 16 km. due west of the Thorne site and is less

than two metres higher in the same basin, that of the River Went, such are the complexities of stratigraphy on the Chase that the Askern site must remain undated until a more detailed investigation can be attempted. In Britain, the larvae of G. nobilis are only recorded from old apple trees and its distribution is entirely southern English, lying south of the 17°C July mean isotherm, although there are apparently old records from Cumberland (Skidmore, 1971). On the Continent, the species is more catholic and larvae are known from oak, beech (Palm, 1959) and willow, as well as fruit trees (Horion, 1959). The imagines swarm in hot sunshine and can be found on flowers, particularly elder (Sambucus sp.) but also Filipendula ulmaria and various Umbelliferae. This chafer is nowhere common, occurring throughout Europe, except Finland and northern Russia. In the South, it tends to be montane and its northern limit is reached in the Oslo district of Norway and in Västermannland and Gastrikland in Sweden (Horion, 1959). It is apparently rather less rare than the other member of this genus found in Britain, G. variabilis (Palm, 1959).

Pyrrhidium sanguineum L.

A head and a fragment of the thorax of this striking red longhorn beetle were recovered from the silts immediately below the Late Bronze Age / Early Iron Age boat at Brigg in the Ancholme valley, north Lincolnshire. This horizon is of the order of three hundred years younger than the Thorne Moor site (^{14}C dates on the boat range from 2500 ± 130 (Q. 1261) to 2672 ± 75 (Q. 1258)) but geographically only 30 km. away. P. sanguineum usually infests recently cut or fallen oak, lying above the ground surface and, in both England (Lloyd, 1950) and Sweden (Palm, 1959), it is restricted to this wood. Further south in Europe it is also recorded in horse-chestnut. sweet

chestnut, hornbeam and beech (Duffy, 1953) and there is one record from pine (Fraser, 1948). In these woods, the species is occasionally imported into Britain and Duffy (op. cit.) has regarded it as doubtfully native. It is now restricted in England to the small area of Moccas Park in Herefordshire, a solitary locality shared with the small Scolytid Ernoporus caucasicus. Both Hickin (1968) and Allen (1973) accept the species as a very rare indigenous insect, its native status being now confirmed by the Brigg specimen. In view of the relative frequency of modern accidental imports of this and other Cerambycids, a process which Osborne (1971) has extended back to the Roman period with the specimens of Hesperophanes fasciatus from Alcester, Warwickshire, the surviving timbers of the boat were examined closely but none of the characteristic galleries of the longhorn were discovered. It remains remotely possible that the insect had emerged from timber in a higher part of the boat, which has not survived, and fallen into the water to be swept under the boat. Since the species oviposits in crevices in the dry bark of freshly dead oak, a single generation being raised from the wood before it becomes unsuitable, either the boat was constructed of unseasoned timber or the insect is adventitious in the deposit and was endemic locally, having flown in. The strong case for the beetle surviving in north Lincolnshire during the Early Iron Age is also propped, if rather negatively, by the fact that the only boats which closely parallel the Brigg example come from the north foreshore of the Humber at North Ferriby, suggesting that the mode of construction may have been a local eccentricity (Wright & Wright, 1947; McGrail, 1975). Although large numbers of larvae may occur in the same piece of timber, such that the insect may be very locally common, its fastidiousness in seeking out freshly fallen dead oak wood not lying on the ground makes it very susceptible to heedless habitat destruction by firewood collection and tidy forestry, factors which may be threatening its continued survival at Moccas Park.

Ernoporus caucasicus Lind.

This small Scolytid was first recorded from deposits ascribed to Pollen Zone VII at Shustoke and at Alcester, Warwickshire, by Osborne in 1964 (Kelly & Osborne, 1965). In the same paper it was noted that A.A. Allen had recently added this species to the British list and his records, from Moccas Park, Herefordshire, were eventually published (Allen, 1969). As its congener E. tiliae Panz., also a rare, if less localised species in England, E. caucasicus is restricted to lime and has only been taken on the small leaved lime, Tilia cordata, at Moccas. In Denmark and Sweden, where it is only recorded from the southerly province of Blekinge (Palm, 1959) it is also more frequently found on T. cordata, although recorded also from T. platyphyllos (Allen, 1969). At Shustoke, where the associated plant material provided a ^{14}C date of 4830 ± 100 B.P. (N.P.L. 39), macroscopic remains of both species of lime were frequent and Tilia pollen formed up to 50% of the total arboral pollen. The Misterton Carr site, with a date of 4330 ± 100 B.P. (Birm. 328) at the base of the peat succession (above, p. 140), lying only 19 km. south of the Thorne Moors site, also provided abundant macrofossils of lime and its pollen reached a maximum of 39% close to the base of the two metre succession (fig. 51). At Thorne Waterside, 5 km. south-west of the Moors, the base of the c. 4 m. succession in the bed of the old River Don included lime seeds and was dated by ^{14}C to 4230 ± 120 B.P. (Birm. 359); from samples examined for insect remains from both these sites Ernoporus caucasicus was recovered. Tilia pollen in Smith's (1958) Hatfield Moors diagram, from only 9 km. north of Misterton Carr, nowhere exceeds 6% during Zone VII (b) but it again approaches 50% at Island Carr, Brigg in the Ancholme Valley (op.cit.). Whilst differential preservation of pollen grains is possible, Godwin (1975) has noted that there is some evidence for Tilia cordata in fen

edge woodlands and for its local dominance in climax forest. In such forests around the Humber, E. caucasicus appears to have been locally common during Pollen Zone VII(b). By c. 3,000 B.P. however, the lime had virtually disappeared from the area. It is absent from the basal part of the Thorne Moor diagram (fig.66) and reaches only 3% of the total tree pollen in the Sphagnum peat, where it is probably represented by grains from stands on the Magnesian Limestone, 16 km. to the west. Similarly in Turner's (1962) Thorne diagram, lime forms up to 2% of the total land pollen. On Hatfield Moors, the continuous trace of Tilia ceases and at Brigg it declines drastically (Smith, 1958) at the Zone VII(b)/VIII boundary and, nationally, this change is one of the factors used to define this zonal boundary at about 2,500 B.P. (Godwin, 1975). Turner (1962), however, has pointed out the diachroneity of this horizon and suggested that an anthropogenic cause may be involved. On the Levels, the decline in lime must partially relate to the rising watertable but continuity of native lime has been argued for woods on the Magnesian Limestone (Jackson & Sheldon, 1948) and it is in these that populations of E. caucasicus might be expected to survive. Place name evidence (Smith, 1951), however, would imply the survival of lime on the Levels at least into the eleventh century. Tilts, 15 km. south-west of Thorne Moors, 6 km. north of Doncaster, is from the Norman French for lime and, perhaps more surprisingly, Lindholme, an island in the centre of Hatfield Moors, where Tilia disappears from the pollen diagram early in Zone VIII, is a place name of Scandinavian derivation meaning island of lime trees. The disappearance of suitable habitats for this small bark beetle on the Levels may therefore be quite late. Such woods, however, have suffered extensive exploitation for leaf fodder, timber and, as Godwin (1975) notes, particularly for bast fibre, and would have been managed on a coppice basis with little

moribund timber and few old trees. Although one has to agree with Allen (1969) that this small bark beetle may have been overlooked in a number of localities, its present rarity must to a large extent relate to the effects of man upon its host.

Ischnodemus sabuleti Fall.

Whilst virtually all the Coleoptera discussed are associated in some way with mature forest, one species of Hemiptera would seem to give a more definite climatic indication. The European chinchbug, Ischnodemus sabuleti, can be found in numbers up to several thousand upon its host plants, which include the reed Phragmites communis and several marsh grasses; in summer migration may take place onto oat grasses and similar plants in dry, sunny fields (Southwood & Leston, 1959). It was in such numbers that the insect was taken on Inkle Moor, adjoining Thorne Moor, in 1972 (Skidmore, 1973), yet when Southwood and Leston published their general survey of the land and water bugs of Britain in 1959, although very common, its distribution was limited to south of a line from Hampshire to Oxfordshire and down to Essex and, prior to 1893, it was only known from a solitary locality in Surrey and Folkestone Warren, Kent. Such a primary distribution and subsequent spread could be taken to imply a recent introduction and expansion as the recent well attested appearance from the Southern Hemisphere of the Lathridiid Aridius bifasciatus (Hammond, 1974). There are, however, two recognised subspecies, I. sabuleti quadratus and I. sabuleti sabuleti, and the former remains restricted to its Folkestone locality although Slater (1960), because of their differing ecological niches, has made a case for the two as separate species. The bug has also shown a similar increase in distribution in Continental Europe, curiously enough paralleled in North America by the spread of another Blissine bug,

the chinchbug Blissus leucopterus, an important pest of cereal crops (Southwood & Leston, 1959). The evidence which finally negates any suggestion of recent introduction, other than by flight of macropterous individuals from the Continent, is a single thorax from Late Bronze Age deposits from beneath the Brigg boat (Buckland, in press). Unfortunately the specimen does not allow differentiation between the two subspecies. It is apparent therefore that, two thousand five hundred years ago, this bug occurred at least as far north as at the present day and has since retracted and again expanded its range. Although Skidmore (pers. comm.) has noted a winter hibernation association with the apparently warmer litter of the reed-grass, Phaleris arundinacea L., the species appears to be fairly catholic in its requirements and abundant habitats, both natural and artificial, have always been available throughout the Lowland Zone. It is difficult to find any factors other than climate to account for its distributional oscillations. Certainly the first half of this century has been marked by an amelioration of the climate (Lamb, 1969) and, allowing for a threshold temperature to which the insect has reacted, it would seem probable that its rapid recolonisation from a refugium in the South-East reflects recovery from the effects of the Little Ice Age. Of recent years a reverse trend in the climate has set in (Lamb, 1974); it will be interesting to note whether the European chinchbug starts to retract its range. In terms of palaeoclimates, however, it allows us to suggest that in North Lincolnshire, on the same latitude as Thorne Moor, at c. 2,600 B.P. (q. 1258 et seq.), conditions were similar if not warmer than the present day.

Discussion: Man, Climate and the British Insect Fauna

The transformation of much of Europe from a wholly forested landscape to culture-steppe and urban karst topography represents the most dramatic change within the Quaternary which was not accompanied by an equally substantial climatic change. The anthropogenic factor was insubstantial in earlier interglacials and the events of the Flandrian stand out as largely unique because of this. Changes in the flora during the Quaternary have been extensively documented, in Britain particularly by Godwin (1975) and the vertebrates have gained similar syntheses (e.g. Kurten, 1968). Several other groups have received attention but insects, probably the most frequent invertebrate fossils in Pleistocene terrestrial and lacustrine deposits, were little studied until the examination of Devensian faunas from Chelford (Coope, 1959), Upton Warren (Coope et al., 1961) and Colney Heath (Pearson, 1961). The first post-Glacial site to suggest significant alterations in the insect fauna, Shustoke, was published some four years later (Osborne, 1965; Kelly & Osborne, 1965) and, over the past ten years, sufficient data have been accumulated to make some attempt at synthesising the available information possible. It must be apparent, however, from the notes on individual species above that no single, sweeping interpretation can cover all the taxa which have changed their distributional pattern over the past ten thousand years. Because of the radically different environment involved, Osborne's (1974) assemblage from the initial Flandrian at Lea Marston is left out of the following discussion.

The concept of a rise to a climatic optimum during the Atlantic period and a subsequent decline, with oscillations, has been widely accepted since the macroplant fossil studies of Sernander (1908) and the pioneer palynological work of von Post (1924) and even

the most stringent critics of the role of climate in forest development (e.g. Smith, R.T., 1972) tend to accept its broader outlines. Recent work on insect faunas of the early post-Glacial (Osborne, 1974), however, has suggested a much more rapid warming than the botanical data might imply and the environment of the Pre-Boreal may have more resembled secondary birch forest in a central or southern European climate than the taiga. Climatic deterioration from a presumed optimum in the Atlantic, however, a fall of the order of 2°C. into the Sub-Atlantic according to Lamb, Lewis and Woodruffe (1966), is difficult to both pinpoint and substantiate since much of the available information is capable of alternative explanations and the caveats of Smith (1965) and Frenzel (1966) on botanical evidence can equally apply to insects outside the strongly xerothermic, and therefore more sensitive, communities of the Devensian and Pre-Boreal. Certain lines of evidence do appear incontrovertible: the retreat of the pond tortoise, Emys orbicularis, to south of the July 18°C. isotherm at the end of the Sub-Boreal (Degerbøl & Krog, 1951) seems particularly convincing and the retraction of hazel in Scandinavia (Andersson, in Godwin, 1975) also appears to be a factor of climate. Yet, it has to be remembered that species close to their distributional limit are more susceptible to changes, edaphic and anthropogenic as well as climatic. In consequence, as the changes across the pollen zone VII(b) to VIII boundary have been shown to be diachronous and frequently at least partly related to human activities, the chronology of the climatic deterioration has been extended and Frenzel (1966) sees a gradual transition to recent climatic conditions over a period c. 1500 to 700 B.C., with the actual moment of change being registered in the biological and sedimentological record at widely varying dates. Archaeologists have tended to be more precipitous in their interpretation. Piggott (1972) places too

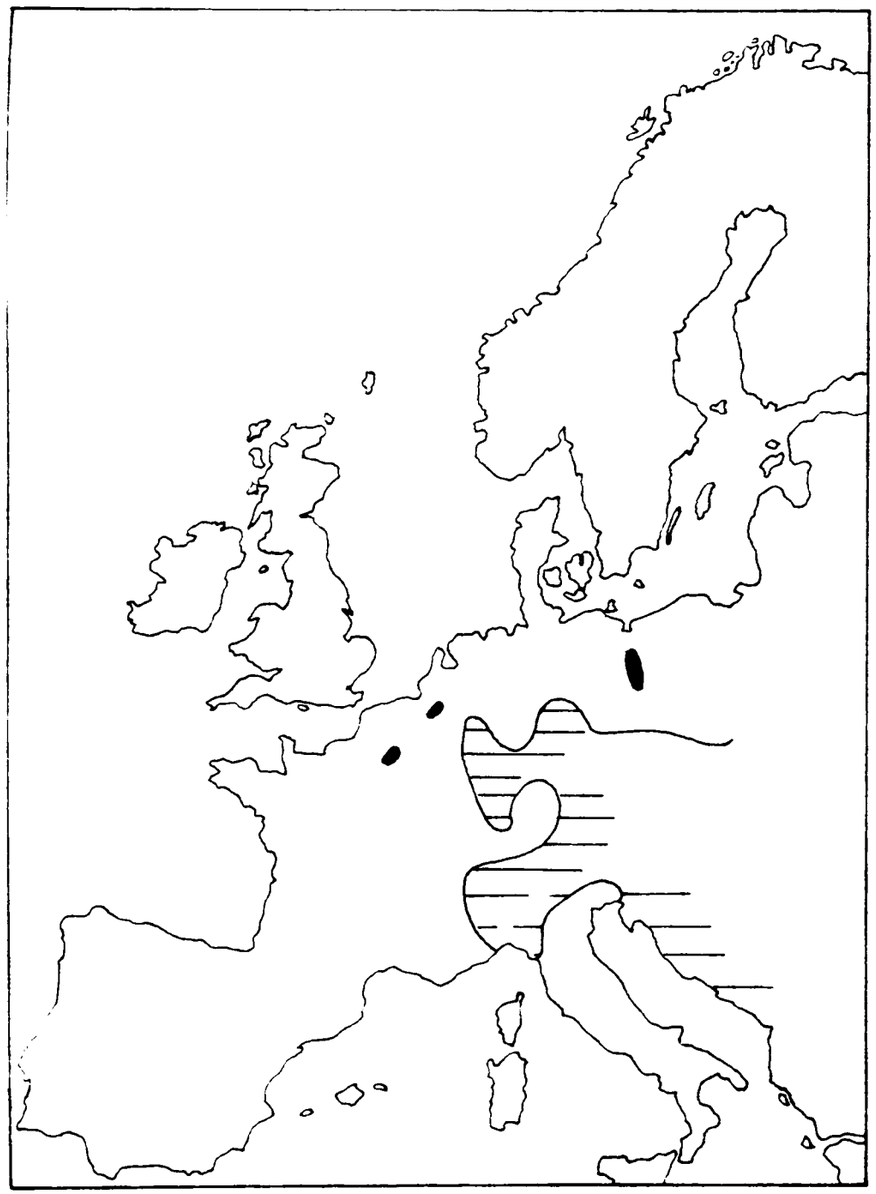

Figure 84. Pertusaria austriacus

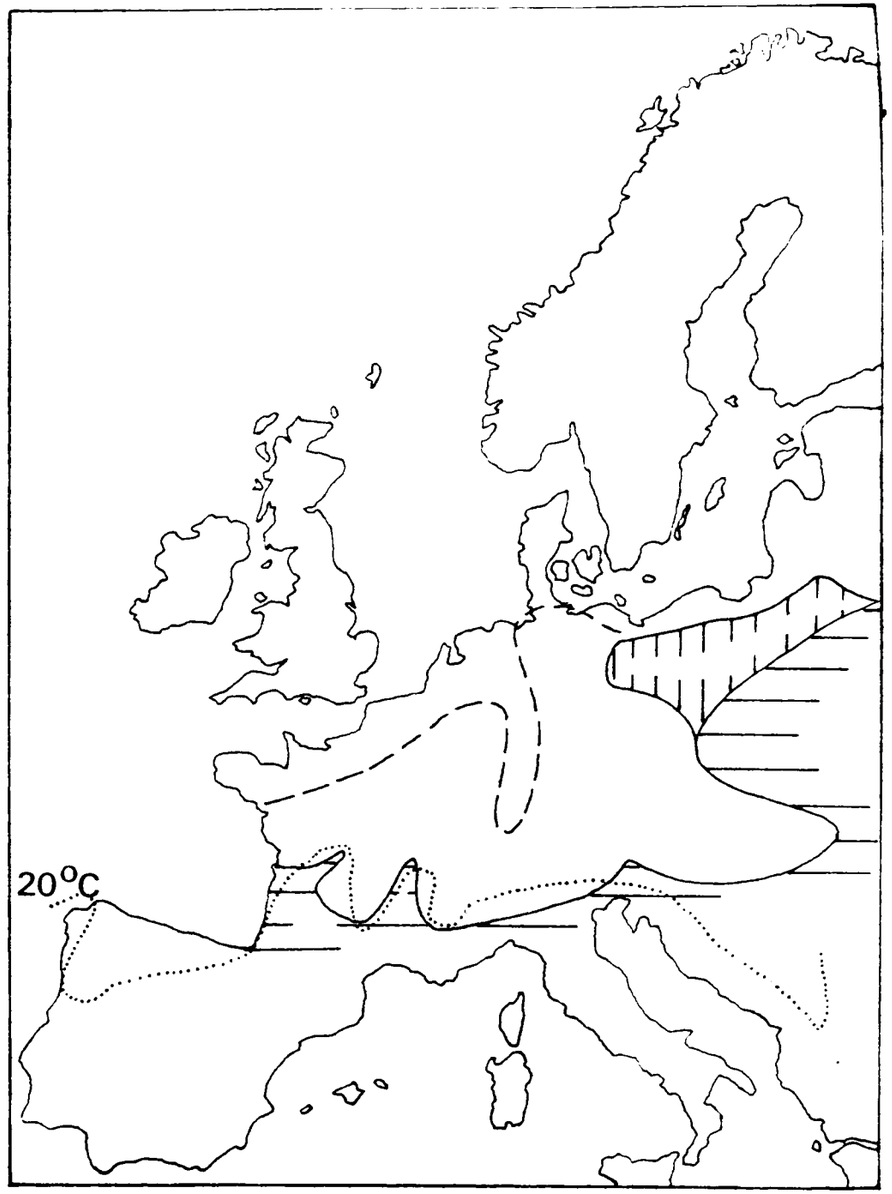

Figure 85. Pond tortoise, Emys orbicularis, dashed line marks limit of non-breeding individuals.

great a reliance upon the correlation of recurrence surfaces in his comments on the Sub-Boreal to Sub-Atlantic transition. Burgess (1974) goes so far as to invoke a climatic deterioration at about 1100 B.C., a change towards a wetter, more oceanic, regime to explain what he sees as major cultural translocation ending the Early Bronze Age.

Whilst the record does not preclude episodes of minor periodicity influencing archaeological cultures, as the historical 'Little Ice Age' did (Lamb, 1965), the insect evidence seems to favour gradual rather than precipitate change. England, at the latitude of Thorne Moors, still had a markedly continental beetle fauna at c. 3000 B.P. and elements of this continentality continue in an attenuating manner through towards the present day, still surviving in certain favoured localities. If one takes as a limiting case, the species which have retreated furthest south and east, then Isorhipis melasoides, restricted to the southern beech forests of France and Central Europe (fig. 69), would imply mean July temperatures of +17°C. and January means of between +3°C. and +5°C, depending upon whether summer or winter temperatures, or both, are operative in controlling distribution. A similar indication is provided by Porthmidius austriacus (fig. 84) from Church Stretton (Osborne, 1972) which, even in Central Europe, is confined to particularly warm localities (Horion, 1956), suggesting that it is somewhat more thermophilous than I. melasoides. A preference for warmer summers and greater continentality of climate is also shown by several species which still occur in southern Scandinavia but are no longer found in Britain (e.g. figs. 71 & 72). Lindroth (1943) has discussed the Swedish status of the ground beetle Oodes gracilis and concludes that it represents a post-Glacial 'Warmzeitrelikt' in the fauna. A Sub-Boreal record of the southern and central European

chafer Potosia speciosissima from Denmark has also been interpreted as implying a warmer climate (Johnson & Krog, 1948). Superficially, therefore, the available insect evidence suggests that summers in the late Sub-Boreal were of the order of 2°C.warmer in northern Europe and also more continental in eastern England. This substantiates the data derived from the pond tortoise, whose current northern limit closely follows the 18°C. July isotherm on the North German Plain and dips southwards, closer to 20°C. in France (fig. 85); during the Sub-Boreal, this reptile ranged throughout Denmark and into East Anglia (Degerbøl & Krog, 1951). Similar estimates have been obtained from botanical data (Godwin, 1975).

In reality, however, as the individual species discussions have shown (above, pp.221-288), interpretation is far more complicated than a superficial examination of much of the distributional data would imply. Although the presence of a species can be shown from the fossil record, an absence cannot be proven because of the incomplete nature of the evidence, a fact emphasised by the continued discoveries and rediscoveries in the present flora and fauna (Hawksworth, 1974). Thus the date of final disappearance from Britain or significant retraction in range can rarely be established for a species and only occasionally is there sufficient information for a dynamic model for an individual taxon to be formulated (e.g. for Xestobium rufovillosum, above p.247 ; Buckland, 1975). The variation in distribution of a single species may be quite rapid and it may not be possible to obtain a correlation with a known climatic event. Manley (1965) has pointed out that climatic instability is a character of the oceanic fringe of north-west Europe and that the intensity of variation probably lies within that currently recorded; the events of a single year or decade may have profound effects on a particular species, although a reaction may not be noted until some threshold is

crossed. If macroclimate is the principal factor in controlling distribution, it is apparent that different species will react differently and succumb to deterioration at differing moments in time. Airaphilus elongatus was present in the Midlands during the Roman period (Osborne, 1974) and has since probably disappeared; Onthophagus nutans finally became extinct in this country early this century (Allen, 1965). Several of the Thorne species may have become restricted as a result of the presumed culmination of the Sub-Boreal to Sub-Atlantic deterioration about 700 B.C. but could equally have lasted until the post-mediaeval 'Little Ice Age', shortly before more detailed recording began. For the more mobile species, the possibility of retraction followed by expansion consequent upon climatic amelioration, as the bug Ischnodemus sabuleti (above p. 287) seems to show, has to be considered.

We remain, somewhat blissfully, ignorant of most of the parameters governing insect distribution and much of the available information relates to species which are either synanthropic or assume pest proportions. Threshold temperatures control the ability to fly of the death watch beetle (Fisher, 1940) and the swarming and breeding of the bark beetle, Ips typographus,(Schimitschek, 1948) but it would be irrational to assume that this is the only factor involved. The avoidance by some species, as Dermestes laniarius (fig. 82), of maritime regions suggests that winter temperatures may also be relevant. Poorly demarcated seasons might lack the necessary thresholds for hibernation, resulting in winter activity, consumption of food reserves and consequent increased susceptibility to sudden frosts. These problems would not be faced by most wood-boring species. An oceanic climate, however, may promote the proliferation of entomophagous fungi and possibly other disease organisms. Abnormally severe winters can cause serious reductions in populations,

as that of 1962-3 did to the introduced Cis bilamellatus (Paviour-Smith, 1969), and warm summers may have an opposite effect. Warm springs, coupled with late frosts can be equally destructive, killing imagines which have been encouraged to emerge early by the premature warmth. A slight climatic change, imperceptible on the large scale, may tip the predator-prey relationship in favour of either local extinction or expansion. Lauscher (1953) noted that, on the edge of stands in Austria, if spring was characterised by several days rich in sunshire, mass emergence of the caterpillars of the moth, Ocneria monacha, a pest of timber, occurred on the warmed trunks before the predators and parasites had come out of the ground, a minor climatic anomaly which resulted in catastrophic damage to woodland in 1946.

By far the majority of the species whose distributional range has declined - over 25% of the Thorne Moors taxa - are associated in some way with woodland, principally with moribund and decaying timber and close examination of records of captures reveals a significant correlation with areas of old woodland and relict forest. In Britain, many find their last refuge in such places as Sherwood, Windsor and the New Forest, whilst Fontainbleau contains similar survivors in France and in the Baltic the small island of Öland, which now has the largest area of continuous deciduous forest in Europe (Sjögren, 1971), forms a similar refugium. The terms 'Urwaldtier', primary woodland animal, and the related 'Urwaldrelikt', introduced by the German entomologist K. Dorn for Rhysodes sulcatus (a species which occurs in the Thorne Moors material) (Horion, 1935), seem singularly appropriate to these insects. Several of the species whose current distribution would seem to contradict the thesis of climatic deterioration, by a northward rather than a southward retreat, fall more into place when their forest relations are considered. Scolytus ratzburgi, from Thorne in the Middle Bronze Age,

occurs from the most oceanic areas of western Scotland across to the most continental regions of Scandinavia (fig. 81) and the one apparent unifying factor is a preference for old established birch forest. Melolontha hippocastani was found by Osborne (1969) in the Late Bronze Age Wilsford Shaft in Wiltshire but, at the present day, it is restricted to the Highland Zone (Johnson, 1962; Sharpe, 1946). This species is widespread on the Continent but restricted to wooded districts, to the extent that its vernacular name in both French (Auber, 1960) and German (Escherich, 1923) translates as 'the forest maybug'. Whilst it cannot be maintained that more semi-natural woodland survives in the Highland than the Lowland Zone, it is evident that edaphic and climatic factors must combine to exclude it from most of England and this distribution can be matched by other species - Sphaerites glabratus (Kelly & Osborne, 1965) and Eremotes ater (above p. 262). Of the species no longer recorded from Britain which have been found fossil, only five cannot be directly related to forest habitats - Oodes gracilis, Airaphilus elongatus, Dermestes laniarius, Anthicus gracilis and Aphodius quadriguttatus. Of these, three relate to fen and other wetland environments, one, D. laniarius, may be anthropochorous (Osborne, 1969) and A. quadriguttatus shows a preference for wooded habitats (Landin, 1961).

The forest provides a particularly stable ecosystem, largely insulated against the climatic vicissitudes of more open habitats. Something of this stability is encountered upon entering a wood from summer heat, high wind or winter cold but equally important in terms of the indigenous fauna is the relative permanence of the environment. In undisturbed forest, with a decay period of ten years and assuming an individual tree lifespan of three hundred years, three or four trees per hundred would be dead and, with a more realistic decay period of up to fifty years, on in eight would be dead (Streeter, 1974) and additional pabula would be provided by partially dead trees.

It is significant that it is the faunal assemblage associated with this aspect of the forest, rotting and moribund timber, that has suffered most since the Sub-Boreal. The thermal stability of the spaces between the trunks in closed forest has been examined by Geiger (1965); nights are warmer and days cooler. In deciduous woodland, winter is marked by increased cold penetration facilitated by the loss of the leaves, although the chilling effect of the wind is mitigated by the trunks and the fallen foliage itself protects a further habitat, the forest floor. The relative warmth of the litter, particularly as a site for hibernation, is apparent from measurements made under broom by Danthanarayana (Waloff, 1968). He was able to show that, during the severe winter of 1962-3, the litter temperature never fell below 0.5°C. Pools and similar habitats within forests also experience a relatively benign regime and several of our rarer water beetles, including Hydroporus scalesianus and H. neglectus (above p. 233), occur in such situations. The humidity factors within the forest are also relevant. Hypulus quercinus (above p.253) prefers shaded moist wood and root stock (Horion, 1956) and the depredations of chafer larvae are less severe in moister, shaded localities (Remezov & Pogrebnyek, 1965). In contrast, the evident Urwaldtier Cerambyx cerdo shows a marked inclination towards isolated oaks in Central Europe (Palm, 1959). Such isolated trees, when dead, however, are prone to heat dessication (Stubbs, 1972), a process which renders the wood unsuitable for colonisation by many species. Whilst such comments are generally valid, it has to be stressed that detailed ecological information is lacking for virtually all the insect species involved; for several, it may be too late to attempt to obtain it.

The effects of extensive forest cover upon the limited open environments and the macroclimate in general are difficult to quantify and much of the available data is debatable. Its role in the hydrological and erosional regimes in considerable (Molchanov, 1960;

Raikes, 1967) but the overall climatic effects may be limited to the relatively ameliorated nature of the smaller clearings (Geiger, 1965), not only those created by natural decay and regeneration but also the more permanent openings resulting from herbivore pressures without the intervention of man (Knapp, 1971). Thornthwaite (1956) found no evidence for changes in regional climates induced by human activity but the transition from a wholly forested landscape to culture-steppe may, in itself, have contributed to our current climatic regime.

Accepting climatic change as a factor in the creation of our present depauperate insect fauna, it is apparent from the disjunct distribution at the present day of several of the Thorne species that other factors have had over-riding influence on dispersal and that the surviving fragments of woods, parklands of the nobility and monotonous monocultures of the Forestry Commission are inadequate substitutes for the primaeval forest. Westoff (1971) has divided the landscape into five categories. His first, the natural, that in which the fauna has evolved, no longer exists in western and central Europe. The subnatural has a native and spontaneous flora and fauna, with minor exceptions and is to a small extent influenced by man. This was the dominant vegetational form from the Mesolithic until the beginning of extensive forest clearance but it is now restricted to the peripheral areas, the tundra and high mountains and a few protected reserves, like the Bielowecza Forest in Poland. The semi-natural, spontaneous but essentially changed by man, as meadow, moorland and coppice, predominated until the end of the nineteenth century but has since rapidly given way as the cultivated landscape, in nearly all its aspects controlled by man, has taken its place. With the exception of those species able to exploit the commercial monocultures or those of eurytopic requirements, the cultivated landscape represents a hostile environment for most species of insect.

The widespread improvement of pasture has probably led to the decrease in dung beetle diversity observed by Johnson (1962) and several phytophages associated with rough grassland have also become less frequent. Raw (1957) suggests that the most effective method of controlling the chafer Phyllopertha horticola, sometimes a pest in pasture, consists in ploughing and re-seeding. Xerothermic species, however, tend to be good fliers with relatively high dispersal potential, able to combat fragmentation of habitat by extensive flight in search of suitable oviposition sites. These species have, on the whole, suffered less from the activities of man, until the advent of pesticides, many having seen an unprecedented expansion of available habitat as forest clearance proceeded. The present fauna, however, remains somewhat out of phase, a basically Urwald fauna occupying a Kulturesteppe, the open ground elements having once been restricted to refugia from the forest, been accidentally introduced by man (below, pp.360-377) or late immigrants. The flooding of the English Channel during the Boreal effectively sealed Britain from all but the most efficient fliers and those arriving by chance aeolian transport in sufficient numbers to establish a breeding population. Leistus rufomarginatus and Amara montivaga have established, or perhaps re-established themselves in England during the past century (Hammond, 1974) and occasional numbers of the Colarado beetle are swept across the Channel by south-easterly winds (Hurst, 1970) but Britain remains essentially poor in species, particularly of Coleoptera, when compared with Central Europe. From the Boreal onwards, the picture has been one of progressive impoverishment in species, in part only balanced by introductions.

Whilst the decline in several open ground insects may be a relatively recent phenomenon, in many cases after something of a floruit, the old forest element has been suffering at the largely

unwitting hands of man for a much longer period. Several have retracted with their hosts. Ernoporus caucasicus, which must have been relatively common at least as late as the Early Bronze Age (above, p.285), would have been seriously affected by the widespread reduction in Tilia at the end of pollen zone VII (b), an event which Turner (1962) has shown to be both diachronous and probably anthropogenic. The virtual disappearance of pine from most of England would have reduced the population of conifer insects drastically and some, perhaps including Eremotes ater (above, p.261) and Hypophloeus fraxini (above, p.254), may have only been reintroduced by afforestation. In East Anglia, both pine and beech became extinct by the late mediaeval period and it has been suggested (Rackham, 1971) that their disappearance relates to their inability to withstand heavy coppicing. Although several species which are relatively host specific have become restricted in their distribution, some apparently more catholic beetles have also been affected. Catholicity, however, may be dependent upon a temperature preferendum; as Allen (1956) noted, a species becomes more host specific towards the limits of its range. Eremotes ater only appears in pine in Britain but has a whole range of deciduous and coniferous hosts in more continental regions. Isorhipis melasoides is recorded from several species of deciduous tree but its preference for beech may have become more decisive during a climatic deterioration, resulting in a gradual extinction from Britain, perhaps before the widespread establishment of beechwoods on the Chilterns during pollen zone VIII.

For the majority of insects, however, it is not the disappearance or restriction of a particular host that has contributed to their decline but the widespread disruption and fragmentation of habitat consequent upon forest clearance. In a landscape which is a mosaic of Kulturesteppe and fragments of Urwald, the problems of

corridors of movement for woodland species would have become progressively more acute as the attack on the forest continued. Having evolved in a world carpeted with continuous forest and immediate proximity of suitable hosts for oviposition, many woodland insects tend to have a very low dispersal potential. Unable to colonise newly created isolated woodland habitats, many insects have become restricted to the more permanent areas of relict woodland. Yet, although Rackham (1974) has shown that some of the Cambridgeshire and East Suffolk woodlands are substantially the same as those when documentary sources begin in the thirteenth century, it is not particularly these and similar woods which serve as refuges for the rare species but the more nebulous forest districts, as Sherwood, Windsor and the New Forest. Here draconian forest laws, instituted by our first great conservationist, William, Duke of Normandy, preserved the forest environment from the destructive effects of pannage by numerous semi-feral pigs, coppicing, charcoal burning and timber collection. The forests of royalty and the aristocracy reached their greatest extent under Henry II, when a third of England lay under its laws (Hoskins, 1955), forming a broad strip of territory through the Midlands from Hampshire to South Yorkshire. It should not be assumed that forest in the mediaeval sense is synonymous with trees. Many chases, as that of Hatfield, lay on marginal lands, fens, bog and moorland. Much of the New Forest lies on the nutrient poor Tertiary beds of the Hampshire Basin and Sherwood lies on the similar podzolised Bunter Sandstone (Hopkinson, 1927) and Drift deposits. Tree cover would therefore tend to be fitful and incomplete. There can be little doubt that the later forest areas of the East Midlands were extensively farmed during the Roman period, perhaps on the basis of intermittent arable in a preponderantly pastoral cycle which the poor soils dictated in the early post-mediaeval period (Emery, 1975).

This phase of widespread clearance seems, on the limited amount of palynological (Smith, 1958; Turner, 1965) and aerial photograph data (figs. 86 & 87; Riley, 1973), to have begun during the Iron Age. Sites, like those at Sandtoft (fig.86) and St. Catherine's Junction on Potteric Carr (fig. 87), are frequent on both the Permo-Triassic outcrops and the Drift and are not restricted to the lighter soils. Associated systems of enclosures and small rectangular fields can be traced virtually continuously from the Doncaster region southwards into Sherwood, where they are occasionally glimpsed through the welter of coniferous plantation. East of Doncaster, similar features appear on most outcrops outside the modern alluvium and the peat cover. Despite the paucity of local Iron Age artifacts, these systems, similar to the 'Celtic fields' of southern England (Bowen, 1961) are, in some instances, demonstrably pre-Roman. At Rossington Bridge, the fields lie oblique to both the fortress, probably of the 50's and 60's A.D., and the Roman road and fields clearly underlie the fort at Robin Hood's Well, north of Doncaster. Surface finds suggest continuity into the Roman period on many sites and a solitary sherd of third or fourth century pottery occurred in the ditch of the Dunsville enclosure (Magilton & Dolby, in press). At Bessacarr, late second century pottery kilns respect earlier field boundaries and the complex appears to have been demolished and returned to agriculture after abandonment (Buckland & Magilton, in prep.). Figure 88 attempts to summarise the available aerial and artifactual data for Roman settlement on Hatfield Chase and across towards Sherwood. Any enclosure, localised from the air, and any significant concentrations of finds implying an occupation site, is surrounded by a circle of 2 km. radius, based upon the average limit of successful land utilisation defined by Chisholm (1968), assuming that such marks a theoretical limit to forest penetration and damage

from each settlement. Known field systems without located enclosures are also marked. It must be apparent from the figure that, by one thousand years after the Thorne Moors site, the inroads into the Urwald were so extensive as to virtually destroy it, replacing it by a patchwork of small fields and conserved, or rather managed, areas of woodland which fulfilled the timber needs of the communities. Similar evidence is forthcoming from much of England, from the gravel terraces of the major rivers (e.g. Benson & Miles, 1974; Hampton, 1975) and the Fens (Phillips, 1970) to the Chalk uplands (e.g. Bowen, 1975) and it is clear that many of the Urwaldtiere of Thorne and other sites must have reached relict status by the end of the Roman period, confined to the surviving fragments of relatively undisturbed woodland and neglected coppice, isolated by great barriers of wholly cleared country along the river valleys and the Chalk and vulnerable to any slight environmental change, from clearance and forest utilisation to minor climatic oscillations.

The termination of the economic stimuli of the Roman occupation and the influx of large numbers of new settlers, beginning in the fourth century, brought considerable changes in the landscape. Something of a population collapse, resultant upon plague or civil anarchy, may well have occurred and, as people returned to a subsistence based economy, much marginal land went out of cultivation. Yet, in part, the collapse is an archaeological one, resulting from the absence of dateable artifacts, and the processes are more probably towards a nucleation of settlements, as Cunliffe (1973) has argued from the Chalton district of Hampshire, than actual decline. Such nucleation, whether for social or defensive reasons, would inevitably lead to the redistribution of woodland and some fresh clearance as woods were consolidated into larger blocks for the needs of each enascent village or group of settlements. In some

Figure 86. Sandtoft, Lincs. (N.G.R. SE743088) : Romano-British enclosures and fields from the south

Figure 87. Potteric Carr, Yorks. (N.G.R. SK592997) : ? Iron Age enclosures and huts from the south

For figure 88, see folder at end of text.

areas this process had begun during the Roman period (op. cit.) and it is tempting to relate the apparent reduction in land under cultivation to the adoption or introduction of more intensive farming techniques, including the growing of winter wheat and the wider usage of manuring rather than unaided fallowing. It has to be noted, however, that the use of manure was not unknown to the Roman world (e.g. Pliny, XVII, 57) and may have been an essential part of the villa economy (Applebaum, 1972). The frequent general scatters of flint debris over considerable areas might also suggest that the merits of midden material were recognised as early as the Neolithic. Whatever the reason, much of what was later to become the chases of Hatfield and Sherwood seems to have gone out of evident cultivation in the post-Roman period. Place-name evidence suggests that it is on the edges of these wastes and the margins of the alluvium, where the character of the deposits had changed considerably (above, p.218), that later Anglo-Scandinavian farmsteads were founded, perhaps after a few hundred years of natural regeneration had somewhat upgraded the poor soils.

It was in such areas of partially regenerated woodland and heath, impoverished by unsympathetic farming techniques and representing but a pale reflection of the Urwald, that the Conqueror placed his protected reserves which, although intended for larger vertebrates, the deer, boar, hare and fox, incidentally provided refuges for forest orientated invertebrates. Outside the game parks, it is probable that Rackham's (1974) comment that, in eastern England, there was not enormously more woodland at the time of Domesday (1086) than by 1945, holds true for much of the country. Certainly by the thirteenth century when the first detailed documents occur woodland had a scarcity value (op. cit.) owned by the lord of the manor and all activities therein were carefully controlled (Bennett, 1937).

Most were clearly defined, often by banks and ditches. At Serlby, on the northern fringes of Sherwood, the park was embanked in 1191 (Court Rolls, unpubl., Dolby, pers. comm.) and the 146 hectares (360 acres) of Edlington Wood, overlying well preserved Romano-British farmsteads (Corder, 1951; Ramm, 1973), is enclosed by an undated bank along the parish boundary. Such woods, where not wholly reserved for private sport, were under heavy anthropogenic pressures and few have formed safe retreats for endangered insect species. Most were managed as coppice with standards to provide building timber cut, on rotation, at three to twenty year intervals, a practice which can be traced back as far as Domesday, where it is referred to as <u>silva minuta</u> (Rackham, 1967). As well as these somewhat periodic demands for large timber and for charcoal, the needs of the community for firewood, oak bark for tanning and withies for wattling, as well as other woodwork, had to be met. Fourteenth century documents record considerable sums for <u>loppio et chippio</u> (op. cit.) and both the twigs and foliage of oak were burnt to provide potash for soap manufacture and bracken undergrowth was similarly exploited (Brown, 1974). Dead wood was not suffered to remain either on the ground or on the tree and the phrase "by hook or by crook" owes its origin to the right to obtain firewood from the lord's wood by these means (Bennett, 1937). Any decaying timber which might escape these pressures outside the actual enclosed wood would be subject to the rooting of pigs; as with sheep in rough pasture, these would preclude natural regeneration and would be effective destroyers of forest floor habitats. The fall in swine assessments between 1066 and 1086 (Rackham, 1974) may reflect a realisation that an essential element in the landscape was being over-exploited, social changes or an actual decline in the amount of beechmast and acorns available as pannage, a practice which is now

only continued in the New Forest (Tubbs, 1968). By the mediaeval period and in some areas earlier, the surviving woodland represented that which was economically necessary to the continuance of the community. It is unlikely that such prolific insect habitats as old oaks would have been present and the oldest trees would have been the pollards of woodland edges, boundaries and pastured parkland, cut above the level of damage by herbivore grazing, poor substitutes for closed forest.

This picture differs considerably from that portrayed by many historical geographers:

> "If one walked half a mile, a mile at the most, out from the village, one came to the edge of the wild, to ... the massed trunks of the primaeval woods still waiting the axe." (Hoskins, 1955).

The idea is still repeated (e.g. Kirby, 1974) and may indeed apply to some areas of royal forest. Even in these, however, there were problems. An impecunious Crown was not averse to assarting and timber extraction, provided due fee was paid, and concessions were given to many monasteries to exploit the forests, as well as supplying royal timber requirements; by the middle of the fourteenth century, the extent of royal forest had fallen by one third (Donkin, 1973). Overstocking with animals for the chase, particularly deer, occurred and fodder had to be provided in winter, implying that over-exploitation was already a problem. Throughout the mediaeval period, a precarious balance existed between population and timber resources, a delicately poised ecosystem which was finally completely upset by the beginnings of an industrialised society in the sixteenth and seventeenth centuries. Concern for timber resources was expressed under the Tudors and the first act for the conservation of woodland was passed in 1543 (Baker, 1973). At a period when climate became more severe than at any time since the end of the Devensian

(Lamb, 1965), the refugia of Urwaldtiere were subjected to increasing pressures. The financial difficulties of successive Tudor and Stuart monarchs resulted in the disbandment of many of the remaining chases and the Dissolution saw the end of extensive monastic woodland. Hatfield Chase, described as 'utterly wasted' in a timber survey of 1608 (Baker, J.N.L., 1936), was disparked in 1630. Iron smelting made increasing demands for charcoal; in 1613 180,000 tons of iron were smelted, requiring 3.6 million tons of timber, four times the current annual extraction by the Forestry Commission (Carlisle & Brown, 1967). Large amounts of timber were also required for other industrial processes - salt extraction and the refining of other ores, and increasing population kept up its needs for wood and land. Industrial activity was particularly concentrated in such areas as the Weald, the Severn Valley, Derbyshire and the West Riding and the Lake District and, by the end of the eighteenth century, when coal had ousted charcoal in most industries, large areas were virtually treeless apart from scrub. Whilst there was some small park creation in the sixteenth century and from the late seventeenth century the landscaped gardens of the new nobility provided fresh habitats, the essential continuity in woodland was broken and some forest insects, unable to reach or find sufficient protection in the remaining woodlands, probably succumbed to the effects of the 'Little Ice Age'. The survivors remained in the often neglected rather than protected royal parks. The 1608 survey of state timber resources records 1,541 decaying trees in Windsor Forest, 34,900 in Sherwood and 62,422 hectares (154,252 acres) of trees in a similar condition in the New Forest (Baker, J.N.L., 1936). These extensive areas of untidy woodland, in the modern forester's sense, were the saviours of many of our remaining Urwaldtiere.

Such a thesis is impossible to prove on the present fossil record but a reasoned case has been made out for the death watch beetle, based upon records from timber framed buildings (above, p.247; Buckland, 1975). More recently, the almost total abandonment of coppicing between the two world wars has resulted in an increase in the amount of unmanaged woodland and therefore of the dead wood habitat but the actual amount of deciduous woodland continues to decline and even important old forest and parkland areas are subject to the over-enthusiastic attentions of foresters, often pursuing a 'perk' to have firewood which has existed since the Middle Ages. By example, in mid-Suffolk deciduous woodland covered 4.4% of the land area in 1837; by 1971 this had declined to 1.8% (Rackham, 1971). The alarming expansion of alien coniferous monoculture has also largely been frequently at the expense of broad leaved trees and concern has been expressed by entomologists at the dearth of decaying wood in old forest areas (e.g. Chalmers-Hunt, 1969; Stubbs, 1974).

The question of conservation of areas containing the remaining endangered forest insects in Britain is a vexed one. Certainly the formation and maintenance of reserves with the minimum of management will conserve already existing populations yet the low potential for dispersal of many forest species means that communities tend to be isolated entities, liable to inbreeding effects which increase the probability of extinction of individual populations (Hooper, 1971). One apparent effect, genetic drift, however, has never been proven and, although Berry's (1971) comment:

> "In general, it seems that if a population of organisms is regularly of so small a size that drift changes can occur, it will be close to the point where it may be unable to survive for ecological reasons."

is perhaps valid, it would be naïve to transfer apparent occurrences in some vertebrate and laboratory populations to poorly studied

invertebrate populations of unknown size. The same idea, stated in a more phylogerontic manner, occurred to Allen (1966) in his discussion of another Urwaldtier, Hylecoetus dermestoides, and he refers to species having "lost the vigour required for spreading"; this contrasts with the more dynamic approach adopted by Southwood (1960), who, in a paper with undertones of Lamark, suggests that insect host preferenda may evolve very rapidly, something which the post-Glacial fossil record does not support. There is little need to evoke any genetic mechanisms. Each isolated community is liable to destruction by local changes, either edaphic or climatic, with little possibility for the immigration of fresh stock. Hooper's disappearing hedgerows are too narrow to form corridors of dispersal for closed forest species and the general outlook for much of our woodland insect fauna is bleak. In many ways, in view of the picture of the history of forest clearance which is gradually emerging, it is surprising that it remains as diverse as it is.

Some form of change is inevitable, as inexorable as Time itself, yet the destruction of the surviving remnants of our semi-natural woodland, the final refuges of a fauna of nearly ten thousand years standing, may be laid at the door of our apparently enlightened and conservation conscious age. Rarely, a dissident voice is raised but most are smothered beneath the complacency of the Nature Conservancy (e.g. Mellanby, 1974). It is hoped that the Thorne data will drive home the magnitude of the changes in one part of the forest over the past three thousand years and that its information can be used to aid the conservation of a much under-rated aspect of the landscape - its insect fauna.

"... baths seem to call for both aqueducts and drains, two features for which Roman civilisation was famous. In Britain we are less well informed than is appropriate about either. In the case of drains, their materials have often been subsequently robbed away, leaving little evidence of character; moreover, the streets beneath which they lie are less rewarding to the excavator than the buildings each side. Aqueducts, on the other hand, tend to escape identification because of the slight nature of their remains, which are easily destroyed by the plough."

Frere (1967)

The Interpretation of Environmental Evidence from a Roman Sewer in York

Introduction

The Roman legionary fortress of Eburacum lies beneath the modern city of York, in the angle between the River Ouse and the small River Foss. Opposite the fortress, on the south bank of the Ouse, lay an extensive civilian settlement, granted colonial status in the early third century, and covering roughly the same area as the mediaeval walled city in this district. The fortress, founded early in the A.D. 70's for the Legio IX Hispania during the advance to the North, covered an area of approximately 20.2 hectares (50 acres) and, rebuilt with a stone enceinte and occupied by Legio VI Victrix, it remained the headquarters of the Roman northern military command until the final collapse of the western empire in the early years of the fifth century. Until the last decade, the relative lack of large scale development and the great depths of archaeological deposits - in excess of 5 m. in many areas - has precluded extensive excavation. The state of knowledge of Eburacum up to c. 1960 has been fully published by the Royal Commission on Historical Monuments (R.C.H.M., 1962) and more recent work is referred to in Butler (1971). During the last ten years, necessary underpinning to the mediaeval cathedral has revealed the plan of the legionary headquarters building (Phillips, 1973) and the pace of redevelopment elsewhere in the city has quickened to the extent that several sites within and close to the fortress have had to be excavated by a specially constituted archaeological research unit, the York Archaeological Trust (Addyman, 1972 & 1975).

In December 1972, a contractor, piling foundations for new shop units at the junction between Church Street and Swinegate in the southern quarter of the fortress (fig. 89), encountered a large slab of Millstone Grit, over 100 kg. in weight. Upon removing the slab, a stone-

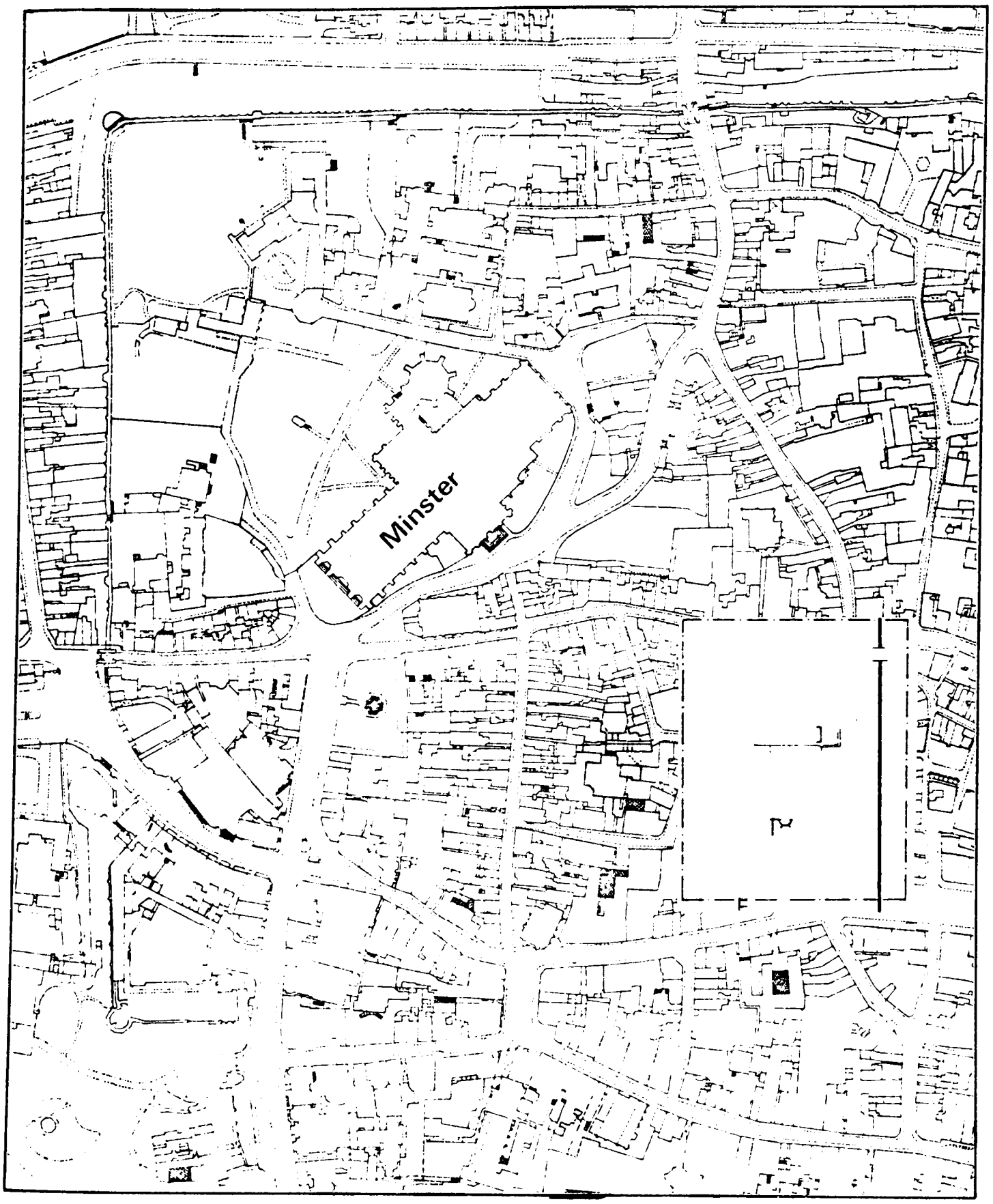

Figure 89. York : the area of the legionary fortress, showing (inset) the location of the sewer and baths (fig. 92).

lined tunnel, 0.5 m. wide and up to 1.5 m. high, partially filled with sediment, was exposed extending for some 40 m. to the north-west and joined by several side-passages from either side. To the south-east, the channel turned an abrupt right angle north-eastwards to continue beneath the line of Church Street, lying just within the Roman defences, towards the gate in the fortress wall which lies beneath King's Square (fig. 92). The developer was prepared to allow a limited amount of rescue archaeological work and lengths of the main and side channels of the sewer were cleared of sediment and recorded. In addition, a small area was excavated down to Roman levels, here represented by a major building with hypocaust, above the line of the sewer in an attempt to establish relationships with any overlying structures. Unfortunately the area examined was both complex and too small to allow much direct correlation and the interpretation of the part of the sewer system examined had to be carried out almost entirely on internal evidence, coupled with judicious use of the evidence of previous finds in the immediate area.

Archaeological Evidence

Because of the nature of the excavation, tunnelling internally along the line of the sewer and removing the sediment, the purely archaeological evidence was of limited value. At no point was it possible to remove the walls of the channel, principally constructed of large gritstone blocks, weighing up to one and a half metric tons, and the small areas of the upper surface of the lintels covering the passage, which were examined, produced no significant finds (Whitwell , 1976). The system, however, did show one major structural modification in that the main channel was diverted into a new parallel alignment joining another large drain from the south-west at right angles in a manhole (fig. 93). The sediment on the floor of the sewer, varying in thickness from a few centimetres at the point of entry to virtually the full depth of the channel

Figure 90. York : the Roman sewer, main channel looking east

(Photo: D.Phillips)

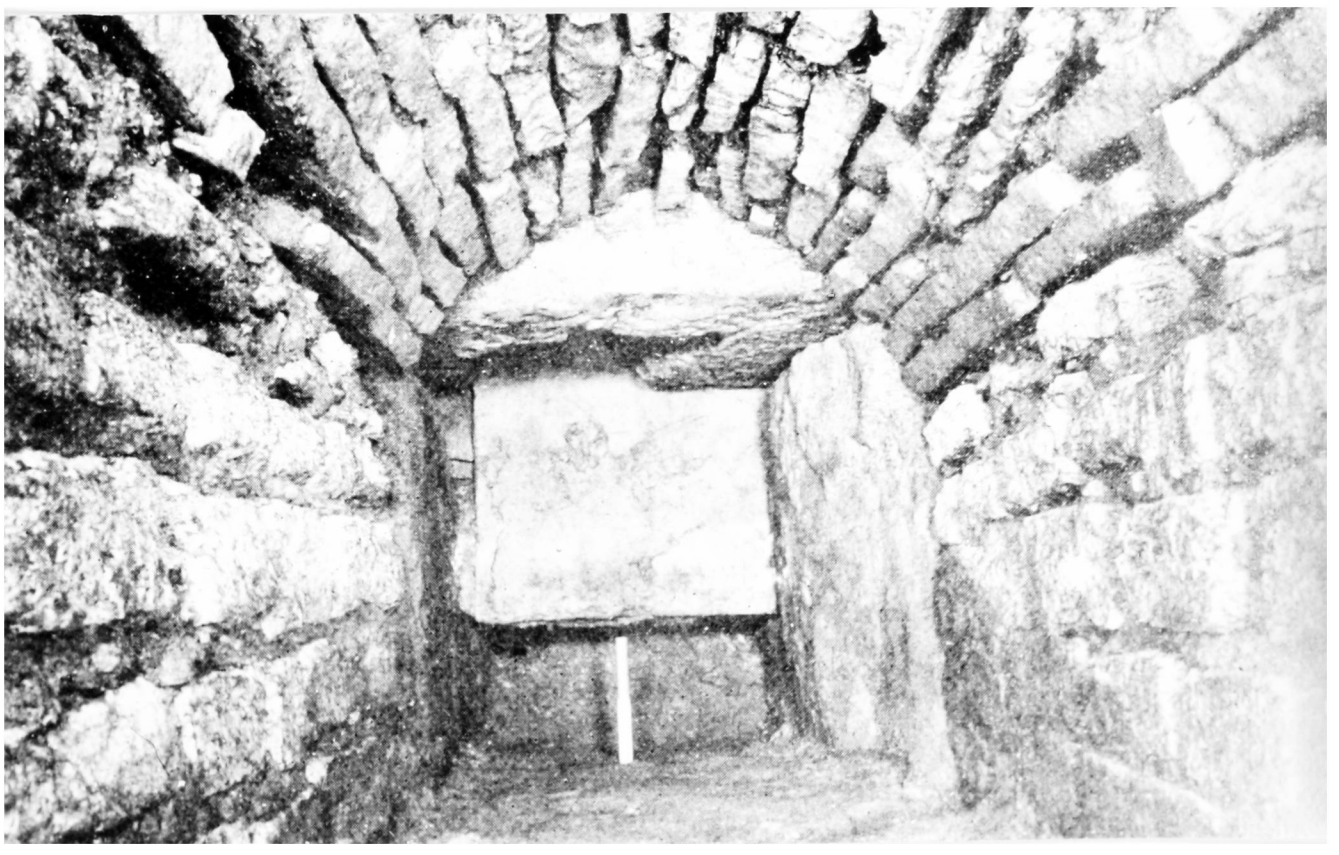

Figure 91. York : the Roman sewer, side passage 6

(Photo: D.Phillips)

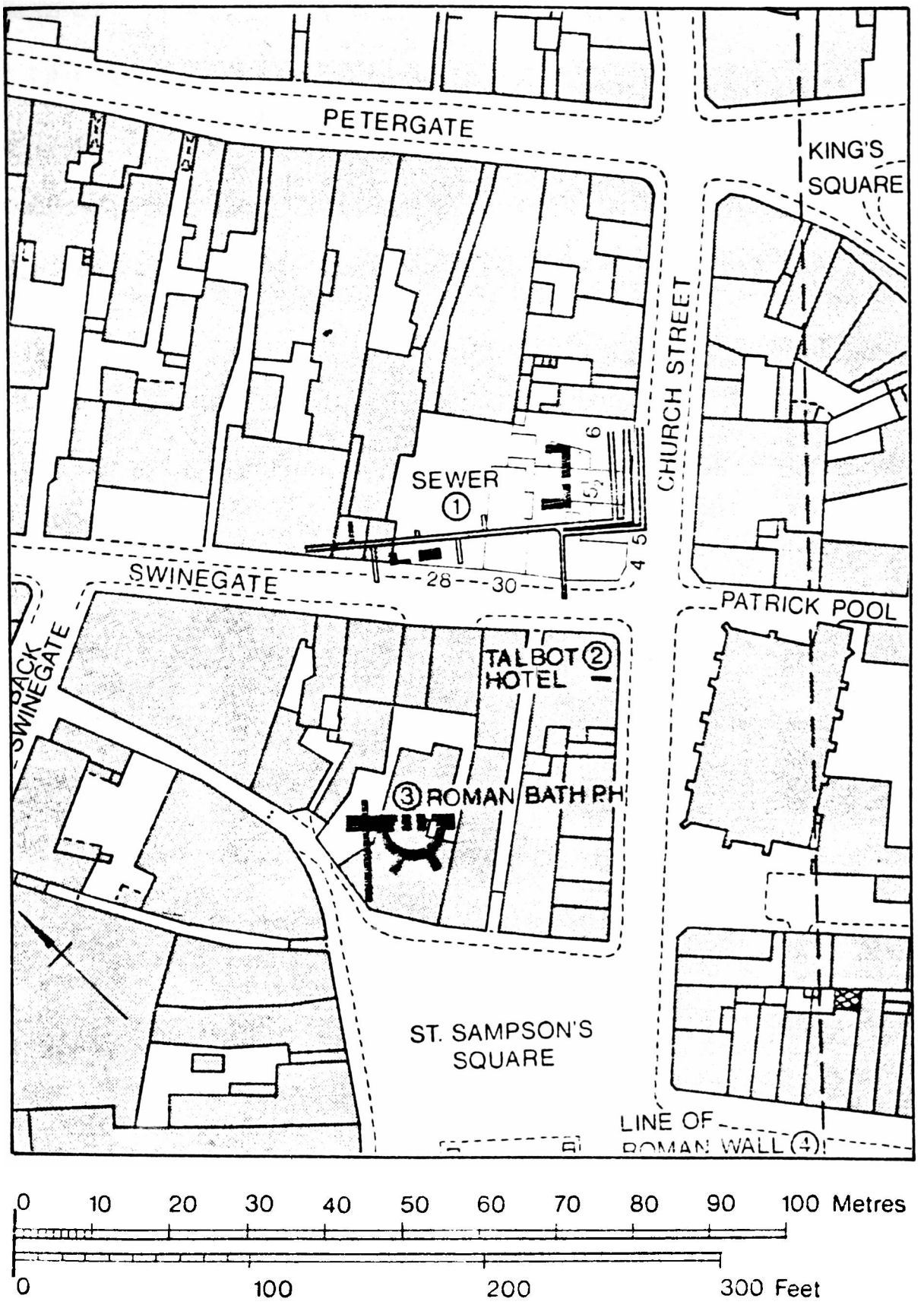

Figure 92. York : location of Roman sewer and baths.

at the north-west limit of the excavated length, contained much Roman pottery (Sumpter, 1976), , a few coins and objects of personal adornment (McGregor, 1976). . The finds, however, must only relate to the final phase of use, or disuse, of the system, when cleaning out had ceased. In the main channel, the pottery sequence included a few pieces which could be dated to the last quarter of the fourth century or a little later. A relatively sharp increase in depth of sediment just beyond the junction with side channel 4 suggested a partial cleaning out up to this point and the remaining sediment contained much more pottery of late second and early third century date as well as a silver coin of Elagabalus (A.D. 218-222). The character of the deposit, however, suggested rapid infilling, perhaps whilst some of the lintels were removed from the sewer during construction work on an overlying building and the pottery could therefore have been strongly residual, arriving in the sewer by disturbance some tens of years after its initial deposition. The short length of the main channel (fig.93) blocked off by the diversion into the later parallel alignment appears to have been allowed to silt up gradually and contained pottery down to the early third century.

The artifactual evidence gave few clues as to the use of the system and the structural evidence provided a minimum of data. There was a slight fall on the main channel towards the line of the fortress wall and it seems probable that it drained out, beneath the roadway through the south-east gate, into the River Foss, about 300 m. to the south-east. All side channels have falls towards the main channel and two (nos. 2 & 4) are less than 3 m. long ending with a vertical chute through the lintel, a few centimetres across, down onto a level step before a slope into the main channel; on the archaeological evidence, it was suggested that these might represent drains from latrines (Addyman, 1972). The standards of excavation were not so high as they ought to have been

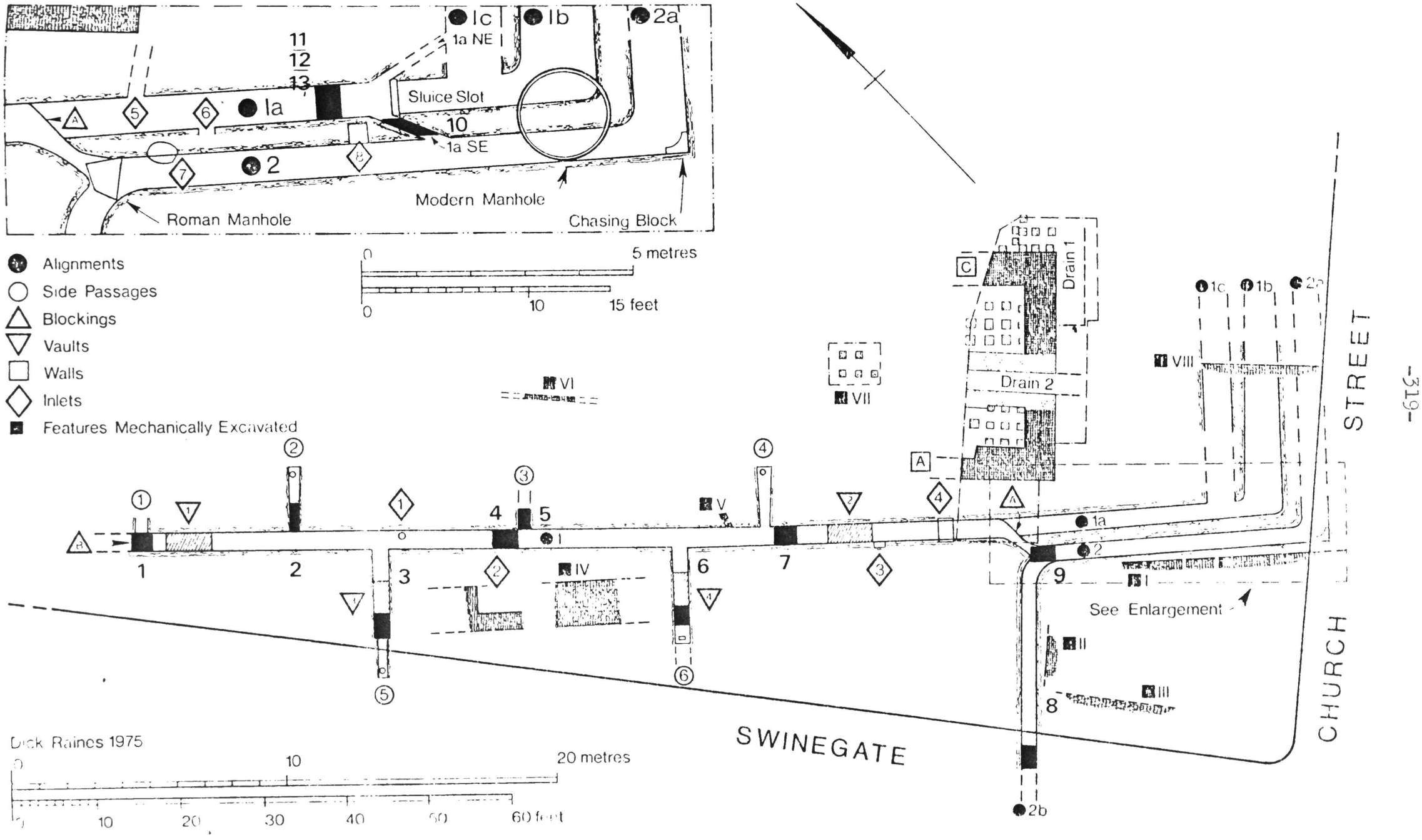

Figure 93. York : plan of sewer, with sample locations (1-13).

but, in mitigation, it must be stressed that the initial allowance of time from the developer was minimal and the people involved in the actual removal of the sediment from the channels worked long hours, often far into the night, in extremely cramped conditions. More exact data could have been gained by careful recording of the positions and attitudes of individual artifacts and a more extensive site sieving programme, but a balance had to be maintained between public opinion and hindrance to the contractors; if the excavation settled down to a long exacting process, public interest would fade and the developer could remove the archaeologists before the section of the system was fully explored. Despite subsequent recriminations, the author still considers that a reasonable balance was maintained but certain lacunae in the recording will become evident in the discussion of the environmental evidence. It was fortunate that the archaeologists involved in the hurried excavations realised that additional information could probably be obtained from the sediments, which, like much of the archaeology of York (Buckland, 1974), was largely waterlogged and the author was allowed to carry out a relatively extensive programme of sampling for biological materials.

Methods

The unsatisfactory nature of the purely artifactual evidence from the channels of the sewer and the very limited character of the excavation of contemporary structures over the system required that, if any detailed information on the usage of the system was to be deduced, a thorough programme of sampling for all possible traces of plant and animal remains had to be carried out. Samples of approximately 15 kg. were recovered from all channels, from the positions indicated on fig. 2. These were sub-sampled for pollen, diatoms, parasite eggs and other microscopic data. A reserve sample of c. 4 kg. was retained from each and the remainder washed out over a 300 micron sieve and the plant and

animal fragments retained thereon separated off by paraffin (kerosene) flotation. Although this method was initially developed for the recovery of beetle and other arthropod remains (Coope & Osborne, 1967), it has been found to be effective for the recovery of most seeds (Buckland et al., 1974). After several applications of the flotation technique, the residue was washed over a 600 micron sieve and dried. Molluscs and small vertebrate bones were then recovered by hand sorting and under the binocular microscope. Arthropod and plant remains from the flotant were sorted in alcohol and mounted on card mounts for identification and storage. The biological materials recovered are now housed in the Environmental Research Laboratory of the University of York.

The sewer did not represent an ideal locality for the recovery of biological remains. The system was not entirely filled with silt and waterlogged, and there was some evidence that the top few centimetres of sediment were being re-worked by an active soil fauna. The possibility of contamination had to be carefully considered throughout the sampling programme. In a number of places the large Millstone Grit blocks roofing the channels had been either removed or broken through in the post-Roman period. Whilst all of these gaps appear to have been immediately backfilled with little or no disturbance of the underlying late Roman sediments, they did allow easier access for organisms to enter the channels and the current coleopterous fauna of the system had therefore to be collected during excavation. Sample locations (fig. 93) were chosen to give the best estimate of use for the various channels. Sampling was carried out by carefully cleaning off the top few centimetres of silt and recovering blocks of the underlying material in large, heavy duty polythene bags, which were sealed to prevent contamination during storage. The thick deposits of the alignment

partially blocked off during the Roman period (fig. 93), were sampled layer by layer; samples 4-13 in this succession, however, contained few insect fragments and in the table of insect remains the results have been combined.

Throughout the system, the sediments consisted of a greyish brown to moderate brown silt (Munsell range 5YR3/2- 5YR3/4), with varying amounts of sand, gravel and rubble. The sediment completely filling side passage 6 contained little coarse material and the amount increased rapidly north-westwards, up the channel, until side passage 3 was partially blocked by coarse sand and rubble, thereby creating a small ponded deposit of gyttja-like consistency. Although almost all deposits certainly remained moist throughout their history, a factor favouring the preservation of organic remains, the coarse rubbly fill of side passage 1 was probably too open in texture to preserve any organic material. The open texture of the poorly sorted sand and gravel filling, intermixed with mortar, limestone and other building debris and much pottery, in side passage 2 and the main channel between side passage 1 and side passage 3 also may have created conditions poor for preservation, and the more calcareous nature of these sediments may have also aided decomposition, as it aided the preservation of mollusca. The absence of insect remains, as well as the character of the deposit, however, could be equally well explained as a result of rapid deposition.

The Insect Fauna

By far the most numerous animal remains were of insects, and it is upon these that any attempt at interpretation must largely be based.

The Modern Subterranean Fauna

Despite the fact that the floor of the Roman sewer lay over 5 m. below the modern level of Swinegate, the parts of the system incompletely filled with sediment possessed an indigenous arthropod fauna,and, in order that the sub-fossil insect faunas could be interpreted, it was necessary to examine this fauna. It has to be stressed that parts of the system had an active soil fauna which was in the process of re-working the top few centimetres of the detrital deposits into a soil and this horizon had to be removed before sampling. In this re-worked layer, a moderate brown gyttja-like mud (Munsell colour chart no. 5YR3/4), the egg cases of earthworms occurred; these were virtually absent from undisturbed samples. In part of the system, particularly close to the initial point of entry, the sediment had been somewhat disturbed by the boots of visitors prior to systematic excavation and, because of the increased possibilities of contamination, it was thought prudent not to begin sampling until the less disturbed area beneath the Roman manhole was reached. Careful and systematic searching of the channels produced one live example of the small, cryptic ground beetle Trechoblemus micros and two live specimens of the Aleocharine Atheta deformis. After the sewer had been under excavation for about three weeks, a living individual of the rove beetle Quedius mesomelinus was taken. Many examples of each of these species were recovered from the samples and, although there is little reason to doubt their contemporaneity with the deposits, these species have to be of limited concern in the interpretation of the biological evidence. When excavation had ceased, the whole system was cleaned out with copious amounts of water and an access manhole installed in the present pavement of Church Street. Subsequent to this, two specimens of Cercyon sp. were found, apparently grazing on the extensive fungal/ bacterial growths on the walls of the sewer, a habitat no doubt exploited

by their Roman precursors. Considerable numbers of living isopods, a few myriapods and some mites also occurred. A few mites and millipede segments were recovered from samples but, since they formed part of the soil fauna, they were not identified. In a subsidiary sample from side passage 3 freshly dead specimens of two species occurred: a single specimen of Atheta deformis and five examples of the small Ptiliid Ptinella Britannica, were still fully articulated and obvious contaminants.

In many ways the modern habitat of the sewer, completely dark, very humid, with some standing water and walls of gritstone and limestone standing around a gyttja-like substrate, is somewhat unusual and it is therefore not surprising that the indigenous species of Coleoptera, Trechoblemus micros, Atheta deformis and Ptinella britannica, have not been taken particularly frequently elsewhere. The ground beetle T. micros, recorded from flood debris and other riverside situations, as well as in the burrows of rodents and moles (Lindroth, 1974), has few other records in Yorkshire, but is perhaps more common in subterranean habitats than is generally realised. In southern Europe it occurs also in caves (Lindroth, 1945), habitats more directly comparable with the York sewer. Fossil records range from the Late Glacial at Glanllynau, Caerns. (Coope & Brophy, 1972) to pollen zone VII at Church Stretton, Salops. (Osborne, 1972) and, in man-made habitats, the Roman well at Barnsley Park, Gloucs. (Coope & Osborne, 1967), medieval sites in York (Buckland, unpubl.) and at Neuss in Germany (Koch, 1971), as well as from the York Roman sewer. Atheta deformis, as the sub-fossil A. luridipennis, from the site, has also been recorded from flood debris (Johnson, pers. comm.). Ptinella britannica has very few other British records, all in the south of England; the small amount of ecological data available suggests that it occurs in

the nesting materials of moles and rodents (Johnson, pers. comm.) and it is possible that the four specimens in channel (1) entered from a rat's nest below a modern building over the sewer, although as a member of the subterranean fauna in synanthropic and anthropogenic habitats, it may be more frequent than the few records imply, a result of the difficulties of collection by entomologists.

Contaminant Fauna

The presence of two species which can be confidently regarded as recent introductions from the Southern Hemisphere, Metophthalmus serripennis and the wood-boring weevil Pentarthrum huttoni, in sample 11, the top sample in the succession from the earlier alignment (fig. 93), requires that the species list from this sample be treated with considerable caution in discussion of the faunal evidence. The intrusive species are themselves of interest since they provide good illustrations of the spread of accidentally introduced species into suitable synanthropic and natural biotopes in Britain.

Metophthalmus serripennis

This small flightless beetle, a native of New Zealand, was first recorded in Britain in 1928 (Stott, 1928) and there are few other records to 1945 (Hinton, 1945). A fungal feeder, it has apparently been imported with straw packing (Halstead, 1959) but has since spread to its natural native habitat in forest litter, etc. (Crowson, 1964). In view of this somewhat unlikely contaminant in the sewer, it is salutary to note that the British Museum Collection includes three specimens labelled 'from dry soil sample, archaeological dig, Thurgarton, Notts., 1948-56'. In Yorkshire, the species has also been recorded from a house in Harrogate (Edwards, 1966), and, in York, it has been recovered, with the other contaminant species,

P. huttoni, from a modern drain sump (Kenward, pers. comm.).

Pentarthrum huttoni

Although first recorded in England as late as 1870, it seemed possible that this species, with its early records concentrated in Hampshire, was a native old forest animal (Urwaldtier), as were the many species with a very restricted British or non-British distribution recovered from Thorne Moor, where the fauna was associated with an area of little disturbed forest of the Late Bronze Age. Certain insects, whose primary natural habitats lay in undisturbed forest, have succeeded in finding acceptable substitute habitats, cushioned against climatic and environmental change, by becoming synanthropic and living within buildings. These include Cryptolestes ferrugineus and the death-watch, Xestobium rufovillosum, (Buckland, 1975), particularly in the northern part of their range. Other species of the genus Pentarthrum, however, are wholly restricted to the southern hemisphere and the cluster of early records around Portsmouth (Fowler, 1887) shows that this wood-boring weevil has been introduced, probably from New Zealand. In continental Europe the species has been recorded from western Germany, Hungary (Horion, 1959) and France (Reitter, 1911), and Reitter's comments also suggest a recent introduction. The present British distribution of Pentarthrum huttoni is somewhat uncertain since there has been confusion with the superficially very similar Euophrum confine, also introduced from New Zealand, about 1937, and now widespread in England (Hickin, 1968). The intrusion of this wood borer into the sewer is difficult to explain but it is possible that the two specimens originated in contractors timber on the site, although flight holes were not noted in any of the props used in the excavation.

Table 12 Insect remains from the Roman Sewer

TAXA	SAMPLE NUMBERS													
	1	2	3(a)	3(b)	4	5	6	7	8	9	10	11	12	13
Hemiptera														
Saldidae														
Saldula prob. saltatoria (L.)	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Coleoptera														
Carabidae														
Notiophilus rufipes Curtis/biguttatus (F.)	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Trechoblemus micros (Hbst.)	-	-	1	3	-	1	3	2	1	7	8	16	7	14
Feronia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Dytiscidae														
Hydroporus palustris (L.)	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Hydroporus sp.	-	-	-	-	-	1f	-	-	-	1f	-	-	-	-
Hydrophilidae														
Helophorus sp.	-	-	-	1f	-	-	-	-	-	-	-	1	-	-
Coelostoma orbiculare (F.)	-	-	-	-	-	-	-	-	-	1f	-	-	-	-
Cercyon spp.	-	-	-	1	-	-	-	1	1	-	-	1	2	1
Laccobius sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Hydrobius fuscipes (L.)	-	-	-	-	-	1f	-	-	-	-	-	-	-	-
Silphidae														
Catops sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Clambidae														
Clambus pubescens Redt.	-	-	-	-	-	-	-	-	-	-	-	-	1	-

Table of insect remains, cont'd.

TAXA	1	2	3(a)	3(b)	4	5	6	7	8	9	10	11	12	13
Staphylinidae														
Omalium sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Lesteva longelytrata (Goeze)	-	-	-	3	-	-	-	-	-	-	-	-	-	-
Coprophilus striatulus (F.)	-	-	-	-	-	-	3	-	-	-	1	2	-	-
Trogophloeus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Oxytelus rugosus (F.)	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Oxytelus sp.	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Platystethus sp.	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Lathrobium sp.	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Staphylinus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Quedius mesomelinus (Marsh)	-	-	-	3	-	-	-	-	1	1	2	55	-	4
Philonthus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Quedius/Philonthus sp.	-	-	-	-	-	-	-	-	1	-	2	1	1	-
Tachinus pallipes Grav.	-	-	-	-	-	-	-	-	-	-	-	2f	-	-
Atheta (Peliolurga) luridipennis (Mann.)	-	-	-	-	-	-	4	-	-	-	-	1	-	-
Autalia sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Aleocharinae indet. (most prob. Atheta spp.)	-	-	2	9	2	8	21	5	-	16	10	186	17	27
Histeridae														
Gnathoncus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Hister striola Sahl./cadaverinus Hoff.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Elateridae														
Adelocera murina (L.)	-	-	-	-	-	-	-	-	-	-	-	-	-	1f

Table of insect remains, cont'd.

TAXA	SAMPLE NUMBERS													
	1	2	3(a)	3(b)	4	5	6	7	8	9	10	11	12	13
Trixagidae														
Trixagus dermestoides (L.)	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Byrrhidae														
Byrrhus sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Rhizophagidae														
Rhizophagus parallelocollis Gyll.	-	-	-	1	-	-	7	-	-	-	1	6	1	1
Cucujidae														
Oryzaephilus surinamensis (L.)	-	-	-	-	-	-	-	2	-	1	-	1	1	1
Laemophloeus (*Cryptolestes*) *ferrugineus*(Steph.)	-	-	-	-	1	-	-	-	-	-	-	-	1	1
L. (*C.*) prob. *ferrugineus* (Steph.)	-	-	-	1	1	-	-	2	-	-	-	1	9	7
Cryptophagidae														
Cryptophagus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Lathridiidae														
Enicmus minutus (L.)(group)	-	-	-	3	-	-	-	-	-	-	-	1	2	-
Enicmus sp.	-	-	-	1	-	-	-	-	-	-	-	1	-	-
Cartodere sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Corticaria/*Corticarina*/*Melanophthalma* sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Colydiidae														
Aglenus brunneus (Gyll.)	-	-	-	-	-	-	-	-	-	-	-	-	4	-
Anommatus duodecimstriatus (Müll.)	-	-	-	-	-	-	-	-	-	-	-	3	-	-
Endomychidae														
Mycetaea hirta (Marsh.)	-	-	-	-	-	-	-	-	-	-	-	2	-	-

TAXA	SAMPLE NUMBERS													
	1	2	3(a)	3(b)	4	5	6	7	8	9	10	11	12	13
Anobiidae														
Anobium punctatum (Deg.)	-	-	-	2	-	-	-	-	-	3	-	1	1	1
Ptinidae														
Ptinus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Niptus hololeucus (Fald.)	-	-	-	2	-	-	-	-	-	-	-	2	-	-
Tipnus unicolor (Pill. & Mitt.)	-	-	-	-	-	-	-	-	-	-	-	1	3	-
Anthicidae														
Anthicus floralis (L.)	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Tenebrionidae														
Tribolium sp. -	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Scarabaeidae														
Onthophagus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1f
Aphodius sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Trox scaber (L.)	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Cetonia aurata (L.)	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Curculionidae														
Hylobius abietis (L.)	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Sitophilus granarius (L.)	-	-	-	-	-	-	-	-	-	1	-	-	2	2
Ceuthorhynchinae indet.	-	-	-	1	-	-	-	-	-	-	-	1	-	-
Hymenoptera														
Formicidae														
Hypoponera punctatissima Rog.	-	-	-	-	-	16	97	11	-	1	-	-	-	-

Table of insect remains, cont'd.

TAXA	SAMPLE NUMBERS													
	1	2	3(a)	3(b)	4	5	6	7	8	9	10	11	12	13
Diptera														
Psychodidae														
Telmatoscopus spp. and prob. Psychoda spp.	-	-	-	1000+	5+	5+	5+	5+	5+	10+	30+	1000+	10+	50+
Phoridae														
indet.	-	-	-	-	-	-	-	-	1	-	-	1	-	-
Sphaeroceridae														
Paracollinella fontinalis (Fall.)	-	-	-	-	-	-	-	-	-	1	-	3	-	-
indet.	-	-	1	1	1	-	-	-	6	-	1	6	2	-
Calliphoridae														
indet.	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Muscidae														
Hydrotaeini indet.	-	-	-	-	-	-	-	-	-	-	-	1	-	-

Table 12, Insect remains from the Roman Sewer, York

f = fragment.(For location of Samples, see fig. 93)

Sample 12, immediately below the one containing the recent introductions, was also slightly disturbed by a rat burrow and included two brown rat (Rattus norvegicus) jaws. This, fortunately, does not greatly affect the interpretation of the insect faunal evidence since all pertinent taxa are those which are associated elsewhere with the system in sealed samples.

Access to the system is now fairly limited, the manhole being lifted for only a few hours each month. The occurrence of arthropoda, particularly insects, is being monitored for comparison with the sub-fossil faunas.

The Implications of the Biota

Whilst the principal arguments are based upon the insect faunas, the evidence of research on other aspects of the biota is used to aid the interpretation. A flow diagram of some of the probable implications of the biological evidence is given in figure 3. The interpretation is complicated by two factors: firstly, the deposits represent either the final phases of use for the system, when cleaning out had ceased, probably during the fourth or early fifth century, or the subsequent period of disuse; secondly, the number of plants and animals represented in the samples is too small to permit any great degree of certainty in interpretation. The great variations in significance for interpretation of the individual species would make any attempt to statistically qualify the degrees of certainty involved spurious, introducing a false numerical accuracy to a study based on many vectors, some wholly intuitive. The fauna and flora are largely of the decay rather than the floruit of the system, when by flushing and manual cleaning the channels would be maintained largely free of silt. Some hint of the late and post-Roman decline and decay of the

fortress might perhaps be gleaned from the flora and fauna. The bottom silts of the primary alignment (fig.93) must, however, have been deposited while the sewer system was in use.

The initial objective of the biological study was to establish whether the system functioned as a foul sewer or as a storm drain, perhaps also taking surplus water from the bath-house, part of which is known to lie to the south of the main channel in St. Sampson's Square (fig. 92) (R.C.H.M., 1962).

In all samples fragments of the pupae of Psychodid flies were common but in side passage 5, from which sample 5 was taken, their frequency rose from a few tens to over a thousand per sample. This was from a very dark grey gyttja-like mud, which appears to have been deposited in a ponded backwater, created by an influx of coarser material down the main channel, obstructing the outflow and allowing water to only filter out through the gravel. This short channel was fed by a small vertical chute through the roof. Some of the Psychodidae probably entered from the outfall where a natural population of larvae would be supported in damp mud by the River Foss, supplied with nutrients from decaying vegetation; these could colonise suitably muddy environments in the system. A fauna of dipterous larvae in a natural habitat largely unpolluted by man, however, is considerably more diverse (Crisp & Lloyd, 1954). It may be significant that the immature stages of Chironomidae and Tipulidae, which were recorded by Crisp and Lloyd in similar natural mud deposits, were absent from the sewer samples. This may relate as much to problems of colonisation and to the exclusion of light from the system as to the nature of the nutrients therein. Some species of Psychodidae are known as 'sewage flies' as they are very tolerant of

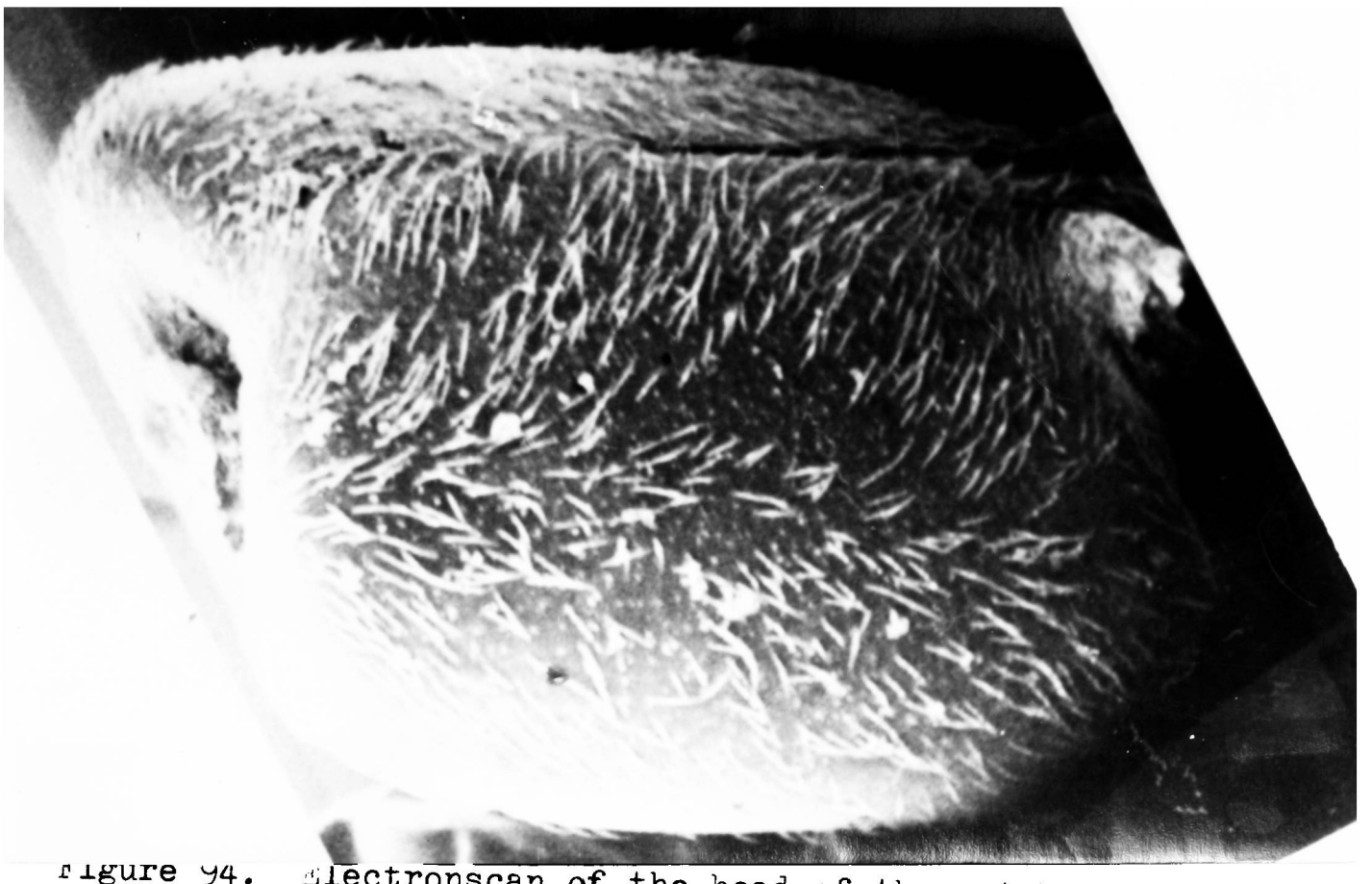

Figure 94. Electronscan of the head of the ant Ponera punctatissima from the sewer showing preservation of setae.

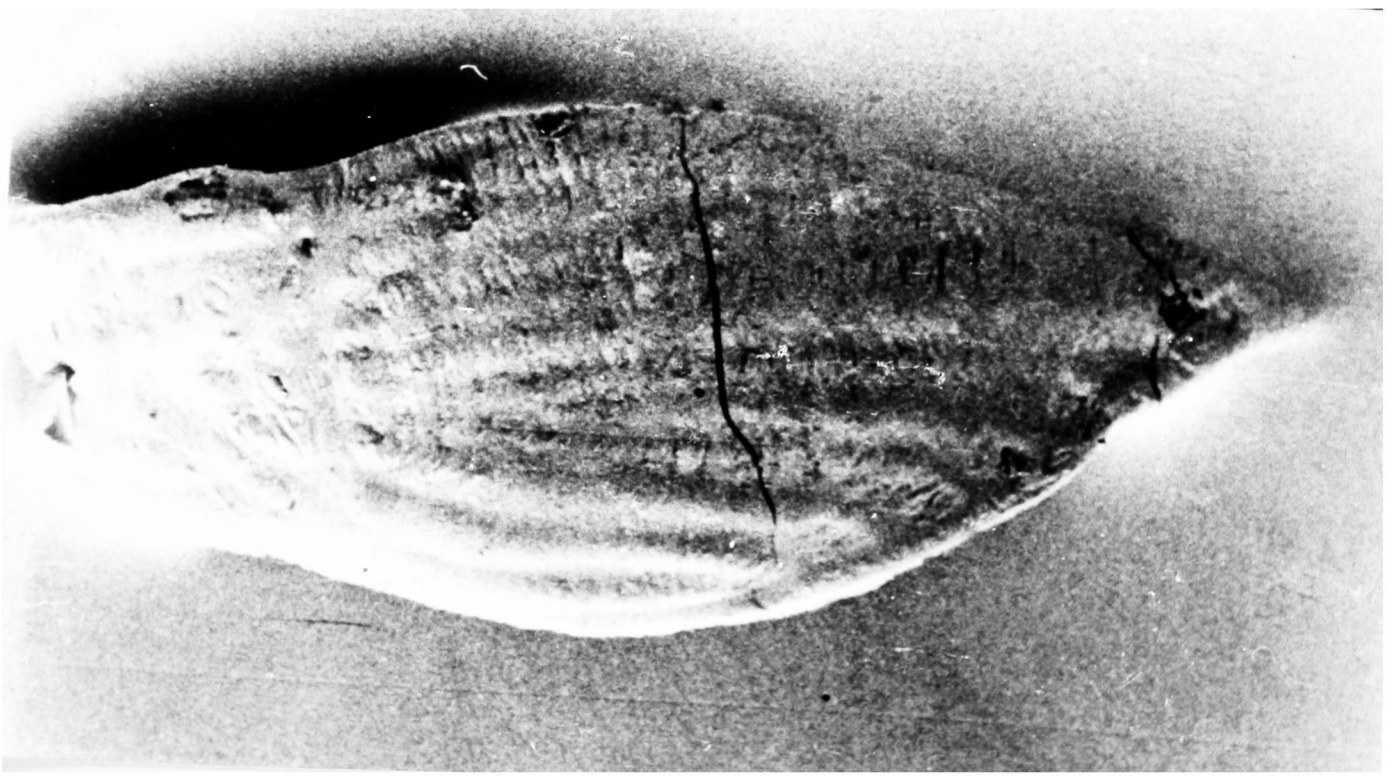

Figure 95. Electronscan of pupa of Telmatoscopus sp.

pollution by raw sewage and thrive on the prolific supply of bacteria, algae and fungi which develop on the filter beds of sewage farms. Chironomidae also form a major component of most filter bed faunas but are less tolerant of very foul conditions (Lloyd, 1944). The examination of anal segments of Psychodid pupae showed that the genus Telmatoscopus was present, an identification confirmed by the impressions of wing venation on pupal fragments (fig.94); this genus has been recorded breeding in shallow slow-flowing water (Freeman, 1950). Some of the wing vein impressions, suggest that the genus Psychoda was also present. Three species of this genus constitute the bulk of sewage farm insect faunas, although filter flies of the genus Metriocnemus are often more frequent in better functioning, more aerated filters (Satchell, 1947). It was not possible to ascertain whether the species of Psychoda were those associated with modern sewage farms.

It is tempting to suggest that this large fauna of Psychodid larvae derived its nutrients from material introduced down the chute as the sample included a grape pip, and seeds of raspberry, blackberry and elderberry, all of which might be introduced in human faeces (Greig, 1976). . There were, however, no eggs of human parasites in a sub-sample from (3), although elsewhere in the system, in the blocked off part of the main alignment, eggs of (?) Trichuris and Askaris were recovered, the latter being restricted to pigs and man (Wilson, 1976). . There is, however, no quantitative data on the degree of infestation in the Romano-British or any other population at this period, and no argument can be based upon this absence. Some support for the presence of excretary products in the system is provided by the abundant sponge spicules noted in all sub-samples taken for diatoms (Greenfield, pers. comm.). A piece of sponge mounted

on a short stick formed the Roman equivalent of toilet paper, with the added advantage that it could be washed out. Martial (Epigrams, 12, 48, 7) comments on the ultimate fate of mushrooms after being eaten - 'nihil, quod sciat infelix damnatae spongea virgae' and Seneca (Epistulae, 70, 25) describes the suicide of a gladiator - 'Ibi lignum id, quod ad emundanda obscena adhaerente spongia positum est. totam in gulam farsit!' Spicules of the freshwater sponge, Spongilla lacustris, occurred in the sub-samples, but this small fragile species is wholly unsuitable for toilet use, but it should be noted that Pliny (31, 11, 47) refers to the use of sponges, either ground or burnt, for medicinal purposes both externally and internally. It is most probable, however, that these spicules derive from the water source for the system. Spicules of one or more species of marine sponge occurred in quantity in the sewer and, if not from medicinal preparations, these probably derive from toiletry usage. It was not possible to identify the spicules to species (Greenfield, pers. comm.) but there are few suitable forms from around the British coast and importation of the bath sponge, Euspongia officinalis from the Mediterranean seems likely. The few passing references to trade with Britain in contemporary sources do not refer to the sponge, probably regarded as a perquisite of a civilised society, but the extent of trade in this item in a less hygiene conscious age is provided by examples from medieval Novgorod, 100 km. east of the Baltic, south of Lake Ladoga (Thompson, 1967). Other possible sources for the spicules have to be considered. Derivation from Palaeozoic or Mesozoic rocks and incorporation in the Drift seemed possible, but the absence of other micro-fossils and the large numbers of spicules preclude this. It can also be added that marine fossils are absent from local Triassic deposits, restricted to a number of discrete horizons in the Upper Carboniferous and relatively uncommon in the

Permian limestones. The marine succession of the Lower and Middle Jurassic outcrops 12 km. north-east of York, but the selective concentration and transport of relatively infrequent spicule microfossils from this source in Pleistocene glacial deposits is most improbable. For similar reasons, an origin by concentration from Tertiary and Quaternary marine sediments incorporated in the Drift from the North Sea basin is equally improbable, particularly since the amount of North Sea Drift in the Devensian Vale of York glacier would be minimal and the material would have to be derived from earlier, perhaps Wolstonian, glacial deposits which are absent or masked by later Drift around York. The only immediate source which needs consideration is the building stone used in the construction of the sewer (Buckland, 1976). The dominant rock, Millstone Grit, is a deltaic formation in its facies suitable for building stone and therefore does not contain sponge spicules. Although two of the other rocks, Lower Magnesian Limestone and a Middle Jurassic oolite, are of marine origin, their usage in the system is too restricted for their slight erosion by the slightly acid ground water regime to have provided the spicule concentration.

Other elements in the fauna from the system support the hypothesis of foul conditions in the sediments, particularly in sample 3 from side passage 3. The only other Diptera occurring in any frequency in the system were Borboridae, represented by puparia. One contained an unemerged adult fly, identified (Skidmore, pers. comm.) as Paracollinella fontinalis, a species not uncommonly found breeding in the surface of filter beds in sewage farms (Richards, 1930) among other habitats. The predators from the system also consist of species tolerant of rather foul conditions. Quedius mesomelinus and Rhizophagus parallelocollis occur in most samples; both are tolerant

of the conditions in rotting, putrid material, the latter being taken frequently from freshly exhumed corpses (Megnin, 1894); both were recovered in large numbers from the sealed lead-lined coffin of Archbishop Greenfield (ob. 1316) from the Minster (Buckland, in prep.), where they had presumably preyed on maggots of coffin flies (Phoridae). Coprophilus striatulus is found in straw, rotting vegetation and in dung, and the Histerids, predators on Dipterous larvae, occur in similar habitats as well as birds' nests. It might be suggested that some of the insect remains, together with the small vertebrate remains, may have originated from owl pellets. The presence of Trox scaber, occasionally taken from owls' nests (Joy, 1932) might be used to support this interpretation, but both small mammal and amphibian remains were found to be generally distributed throughout the system and alternative individual interpretations of their occurrences are to be preferred. It must be emphasised that too much weight in interpretation cannot be placed upon single specimens in the faunal lists, since these may be adventitious and some, like the slow worm (Simms et al.1976) perhaps, may be accidental introductions by man.

Among the remaining insect fauna, certain species of Cercyon, Oxytelus, Platystethus and Atheta occur on modern sewage filter beds (Crisp & Lloyd, 1954) and could have lived in or been attracted to the sewer whilst it was functioning. Some of these probably travelled up the sewer from the outfall by the River Foss, as did the frogs and toads, bones of which were recovered from most samples (Simmset al.1976). The amphibians were probably attracted by its damp, cool atmosphere and perhaps by clouds of flies emerging from the outfall. The atmosphere probably also attracted Atheta luridipennis, not uncommon in flood debris, although this species becomes more strongly synanthropic

in the northern part of its range (Larsson & Gigja, 1959), and could equally have arrived from one of many other man-made habitats within the fortress. The one moderately well-preserved Helophorus, and the predatory bug Saldula (?) saltatoria could have come from the banks of the river, although the latter is apparently not tied to damp habitats (Kenward, 1970) and occurs in modern terrestial deposits in York. The water vole (Arvicola terrestris), frequent in the system, (Simms et al.1976) is another vertebrate which could have been introduced from this source, although many rodents may have arrived through the building.

Although the preservation of insect remains in all samples is moderately good, the numbers of individuals (with the exception of the Psychodidae) are rather small, which imposes certain limits on the treatment of the data. The virtual absence of phytophages and the expected general outdoor fauna of the fortress, however, is significant. Initially the vertical chutes were regarded as drains from either the roadside or the outsides of buildings. The faunal evidence fails to support this interpretation; there is little of the insect fauna which should occur down such drains, which would function as pitfall traps - there are only two dung beetles, Onthophagus sp. and Aphodius sp., and not all species of these genera are restricted to herbivore dung habitats, and only one individual of a genus of ground beetle, Feronia sp., common around buildings. The insect fauna is dominated by more strictly synanthropous forms, which must have lived inside rather than outside the buildings, and their distribution in the various channels of the sewer can be used in interpretation (fig.96).

The molluscan fauna from channels 6 and 7 (Cameron, 1976) supports the archaeological inference that these are the principal

overflows for waste water from the legionary bath-house, known to lie to the south of the system and partially excavated in 1930 (fig.92 R.C.H.M., 1962), but the paucity of water beetles is perhaps surprising. The larger of the channels,2b, appears to have silted up gradually, perhaps after the system went out of use, and the fine silt contained little material, the acidity only allowing the preservation of a single operculum of a freshwater gastropod. Infilling was perhaps more by gradual seepage from the baths than by direct flow, which would limit the introduction of faunal remains. There was also very little artifactual material from this channel. Any open body of water, or indeed a dark, shiny object, as a motor vehicle, will attract flying insects associated with water and it, therefore, seems unlikely that there was any pool open to the sky in the bath-building. The area below the Roman manhole (fig.93) produced two water beetles, Coelostoma orbiculare and Hydroporus sp., and these, as the few others from the system, were represented by single battered fragments. One possible explanation for the paucity and condition of the water beetles is that the water supply came from a spring source down a closed aqueduct feeding the bath-house, itself a vaulted and wholly enclosed structure. Hence few beetles could enter the supply and those that did were rolled and battered in passing down the aqueduct. The excavated area of the bath-house at York is insufficient to provide any information on this aspect, although clearly the one heated room located was vaulted (R.C.H.M., 1962), and, in view of the relatively limited amount of data obtained by normal excavation processes in the restricted areas available on urban sites, it is doubtful whether it would be possible to ascertain whether any unheated pool located was vaulted or otherwise. The relative frequency of the furniture beetle, Anobium punctatum, occurring in most samples, cannot be used to support an argument for wooden roof trusses since it will attack any available timber from

furniture to firewood. The consideration of archaeological and architectural data from better preserved and more completely excavated bath-houses elsewhere in the Roman Empire provides some parameters for the suggestion based upon the insect fauna. The best preserved bath-houses, the Hunting Baths at Leptis Magna in North Africa (Ward-Perkins & Toynbee, 1949) and those of Pompeii and Herculaneum (Wheeler, 1964) are wholly vaulted with only the attached exercise yard unroofed, but the relevance of these civilian suites in the Mediterranean region to military practice towards the northern edge of the Empire can be doubted. More directly relevant, the internal legionary bath-houses at Novaesium (Neuss) (von Petrikovits, 1957) and Vindonissa (Vindisch) (Laur-Belart, 1935) in the Rhineland appear to have been fully roofed. An unheated pool, open to the air, would tend to be unusable for at least part of the winter in northern Europe, although the uncompleted late first century bath-house at Wroxeter, probably intended for Legio XX, (Webster, 1970), was initially planned with a large outdoor swimming pool (Collingwood & Richmond, 1969). The archaeological evidence is therefore inconclusive.

Other aspects of the environmental research provide some clues as to source and state of the water in channel 2(b) The diatom flora is unfortunately restricted to the single genus Nietzchia (Greenfield, pers. comm.) and species of this genus occur in a wide range of bodies of water from polluted slow flowing to waterlogged soils. The freshwater molluscan fauna (Cameron, 1976), however, was most diverse in channel 6 and they suggest that, at some stage, perhaps after the baths had largely fallen into disuse, the flow of water was sufficiently clean to allow filter feeding lamellibranchs to live in the system or immediately above in the baths. Two specimens of Pisidium sp. were found with the valves still tightly closed,

showing either rapid burial by an influx of the fine silt which filled the channel, or that they were washed alive into the channel with the silt. Young freshwater snails and lamellibranch larvae could be introduced down an aqueduct, but it is doubtful whether enough light would be available in a closed bath-house for the development of sufficient vegetation in the leets for the phytophagous freshwater gastropods to mature. Certainly from personal observation within the vaulted part of the Stabian Baths in Pompeii, the structure was far too dark for satisfactory plant growth. The gastropod and insect evidence is therefore apparently contradictory. It is possible that the relatively bouyant empty shells of Bithynia sp., Lymnaea spp. and Planorbis spp. could have been swept down an aqueduct from a reservoir serving the baths. Their relatively fresh condition does not contradict the battered fragments of water beetle, since, with air trapped in the whorls, they would float more readily than the more dense, dead insects which would be scuffed and battered along the floor of the channel. From the seed evidence Greig, (1976) has suggested that rushes may have been utilised either as flooring material, a process for which there is ample archaeological and documentary evidence (Buckland, 1974), or to suppress unpleasant odours arising from the sewer. It is possible that some freshwater snails were introduced with this material since several wetland and riverside plants could have been collected with the rushes, but these are not represented in the seed remains as they were not in seed at the times of collection. On the Anglo-Danish site beneath Lloyd's Bank in York, a wide range of plants, perhaps raked up from flood debris, was employed for flooring (Buckland et al, 1974). The frequency of shells, however, and the presence of freshwater lamellibranchs renders this explanation less probable. A further interpretation, allowing a non-sequence in the sedimentation not apparent in the sewer stratigraphy, is in agreement

with a local place name, Patrick Pool, which was in existence by the thirteenth century (Palliser, 1976). . Raine (1955) has suggested that this might refer to the flooded site of the Roman bath-house, The water supply might have continued to arrive at the derelict baths down an aqueduct. Although overflow into the sewer could still occur, the normal outlet was blocked and a large pond was created over the site of the baths. Only in times of heavy rain did water swirl in quantity down the sewer, taking sediment, mollusca, some insect and plant remains with it. This explanation has little to commend it. The exact meaning and origin of the place name remains obscure and there is little need to evoke an aqueduct to create a marshy area in this part of York, since the impedence to drainage created by the wall and rampart of the legionary fortress, east of Church Street, could have been sufficient, although Raine (op. cit.) suggests, implausibly, the collapsed hypocaust as a cause. The flora and fauna recovered from the sewer lacked the usual components in a pond environment and, although a rapid influx of silt from this source may have created a biased sample, the absence of pond species of ostracods and cladocera, as well as caddis larval tests is probably significant. The ostracod faunas (Meyrick, 1976) consist of only two species, Candona parallela and C. candida, both benthic species, often cavernicolous. These probably lived in the system and suggest only sufficient water flow to avoid stagnation; there were no significant differences between ostracod samples from the various parts of the sewer.

The pollen record from channel 2b can be taken to support the suggestion that water was transported in a closed system from some distance. (Greig, 1976). . The closed, mixed oak woodland spectrum is most improbable for the immediate environs of York in the late Roman period since recent aerial work (Riley, 1973 & above p.303)

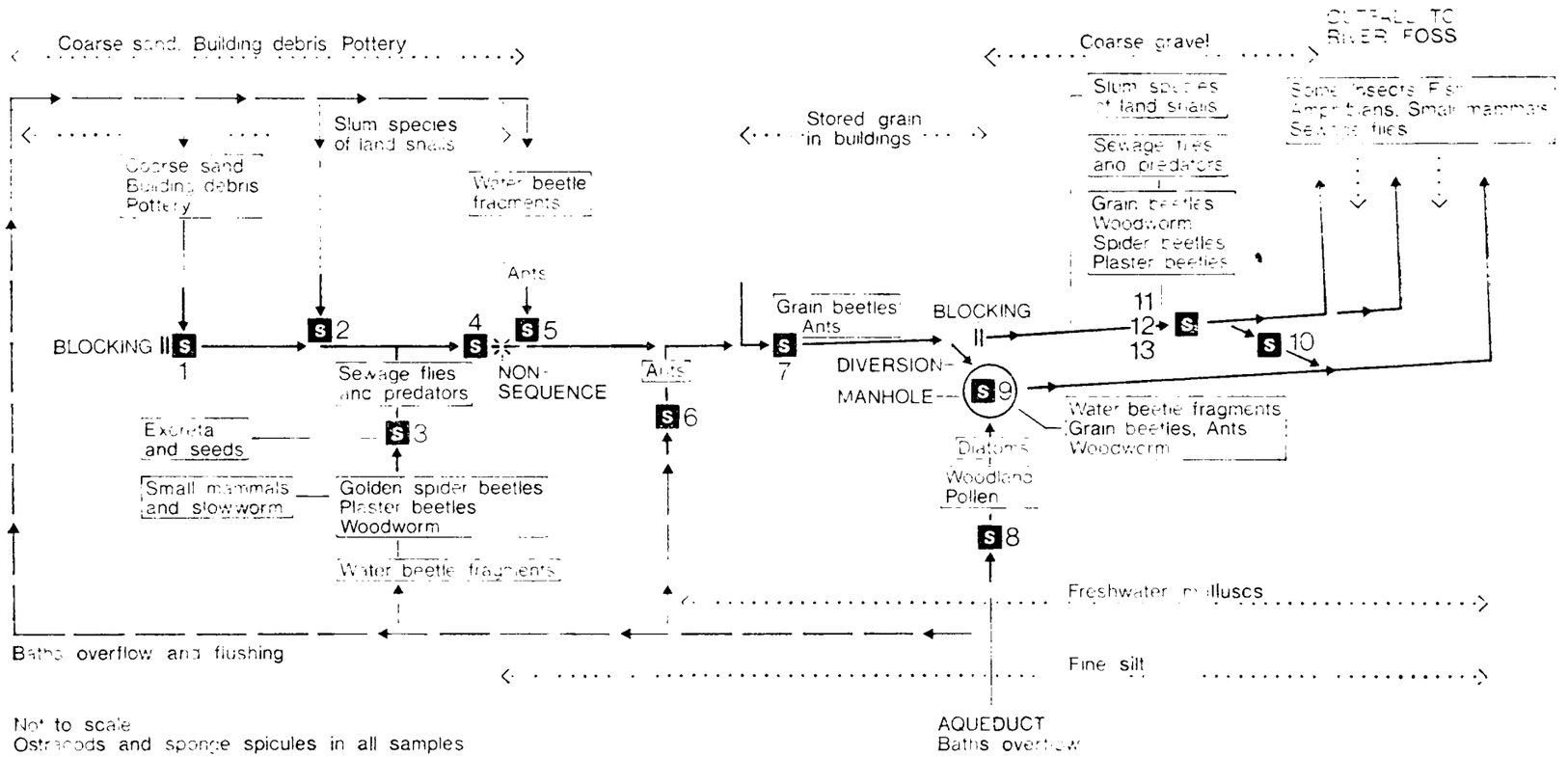

Figure 96. York : a tentative flow diagram for the Roman sewer.

has shown that the dipslopes of the Magnesian Limestones and the Trias were extensively exploited during the Roman period. The apparent dearth of sites on the more clayey substrates is probably the result of the difficulties in detecting sites from the air on these subsoils. In the Vale of Pickering, the artifactual record is in fact better on the clays than on sites located from the air on the more yielding soils (Ramm, pers. comm.). Interpretation, however, is not simple and is complicated by many unknown factors. The problems of the post-Roman period in York and the surrounding Vale, which have already been raised in the discussion of the deathwatch beetle (Buckland, 1975 & above p.247)and are further discussed in connection with the golden spider beetle (Buckland,1976 and below p.362), are pertinent to the pollen data. Because of the virtually aceramic nature of the greater part of the fifth and sixth centuries, and also the nature of the filling of channel 7, chiefly fine humic material with a little sand and gravel, it is impossible to ascertain when the sediment sampled for pollen arrived in the channel, and the spectrum could conceivably represent post-Roman woodland, regenerated over former arable and pasture. Yet it is difficult to envisage a return to woodland, with heath on the poorer soils, up to the walls of sub-Roman York. The fire and sword Tabula rasa hypothesis of the days of Collingwood and Myres (1937), with Saxon occupying an almost deserted, devastated land, has given way to a more balanced assessment which argues for continuity of land usage if not tenure (Taylor, 1974; Fowler, 1975). There can be no doubt that some, perhaps more marginal areas went out of cultivation with the collapse of the Roman economic organisation but the population, if declining, did not disappear and a change to more subsistance based farming, with consequent decline in urban centres, would not have created a woodland pollen diagram in the centre of Roman York. Shotton (pers. comm.) has raised the possibility

that pollen in the sewer could have been introduced in human faeces, having largely originated in honey, mead or other food eaten by the Roman population. Although there is a large body of information on the selectivity of bees in pollen collection (e.g. Ribbands, 1953), and several Classical references (Pliny,11, 5 , 4), it is difficult to provide much useful comment on this suggestion, other than noting the possibility. Any honey need not have come from local hives and, therefore, the resultant diagram from the sewer need not relate to the York region at all. Bees, however, are known to be quite selective in their pollen and nectar collection (Proctor & Yeo, 1973), although clearly the character of the local flora and topography influences collection, and biases towards particular plants could be largely evened out over the collecting period. In terms of honey yield, that from closed, mixed oak woodland would be considerably inferior to that from a more open, more diverse habitat. Indeed, the difficulties of collection from woodland when compared with pasture and parkland, make it a poor habitat for the honey-bee, although the local human population could have shown a taste preference for such honey. The character of the spectrum, closely similar to many others from sub-aerial assemblages, makes honey a less likely source. Although bees do visit wind pollinated trees (Chambers, 1945), some preponderance of pollen from entomophilous plants could be expected, and it is not uncommon to find honey which is at least claimed by the vendor to be derived from a particular group of plants, frequently clover. Oak is only casually visited by bees for pollen (Proctor & Yeo, 1973), and this tree should therefore be under-represented in a honey based spectrum when compared with a normal pollen assemblage. On balance the lack of any marked preferences for particular plants or groups of plants makes an origin in honey or mead unlikely, and the absence of other evidence for herbivore dung, which would, in any case, show a tendency towards

more open habitats, precludes this also as a possible source.

Taking into consideration the other lines of evidence, particularly the vast amounts of water required for the large bath-house attested in the Colonia on the south side of the Ouse and the evidence for piped water supply as well as bath-house in the fortress (R.C.H.M., 1962; Whitwell, 1976), it would not be improbable that an aqueduct, or indeed a number of aqueducts, were constructed for supply. On the Continent extensive supply systems are frequent (Grenier, 1960), and there is a contemporary account of the aqueducts of Rome (Frontinus - De Aquis Urbis Romae). In Britain the evidence is less extensive. The Colonia at Lincoln was, in part, supplied by a concrete-cased earth-ware pipe running for nearly two miles along the escarpment (Whitwell, 1970), and open leet aqueducts of several miles in length were constructed for several towns and forts, including those in the Pennines (Tomlin, 1973 & refs. therein). Transport of pollen down a closed aqueduct from an area of woodland therefore seems possible. The relatively large amount of lime (Tilia) pollen might imply a slightly calcareous, well-drained substrate and this tree is often dominant in areas of naturally regenerated woodland on the Magnesian Limestone at the present day. Two sites which show lime dominance in regenerated woodland south west of York, Edlington Wood (Shimwell, 1973) and Markland Grips (Jackson & Sheldon, 1949), overlie 'native sites' of the Roman period (Dolby, 1973; 1975), and an origin for the sewer pollen in an area of reforested farmland west of York is possible. In view of the problems of interpreting pollen spectra from unnatural assemblages and the present meagre state of our knowledge of the local flora, it is not possible to take this line of evidence beyond this tenuous hypothesis.

Despite the several lines of environmental evidence which seem to be best resolved by postulating an aqueduct to supply the bath-house, it must be remembered that there is, as yet, no concrete archaeological evidence for its existence. A source on the dipslope of the Magnesian Limestone would have to lie north of Tadcaster and south of Knaresborough to avoid crossing the valleys of the Wharfe and Nidd respectively, and the Ouse would inevitably have to be crossed on an inverted siphon, perhaps on the Roman bridge, examples of which are known in Gaul (e.g. Lyons-Grenier, 1960). Several separate sources for settlements on the south and north bank would, however, seem more feasible and for the fortress the most practical would seem to lie north of the River Derwent in the Howardian Hills, up to 20 km. north east of the city. The failure to detect any aqueduct could result from its earthenware pipes resembling land drains or its deep burial, although it is surprising that no extensive linear features have been picked up from the air. Lead water pipes, as those found beneath the fortress intervallum road beneath Church Street (R.C.H.M., 1962), need not imply a continuous pressurised supply since the feed could easily be from cisterns strategically placed to collect rainwater on the roofs of buildings, yet the volume of water required to maintain the bathing establishments and flush out the sewerage disposal systems efficiently could only be adequately met by continuous supply. It is significant that the smaller Roman drain located by Philips (pers. comm.) beneath the Minster was still flowing, and it remains possible that the Roman military engineers tapped natural groundwater distributaries in the Drift to flush out their sewers. One can surmise no further on the environmental evidence and further information will only be forthcoming by chance finds, aerial reconnaisance and fieldwork, coupled with not a little intuition.

Throughout this discussion it has been assumed that the sewer sediments were contemporary with the final phase of use or subsequent disuse and decay of the fourth century bath-house beneath St. Sampson's Square. The excavator (Corder, 1933), however, found that the hypocaust in the caldarium had been destroyed and the cold plunge bath filled in during the late fourth century and the bath-house put to some other use. The date of this rebuilding is uncertain since Corder's date relates to the latest dateable artifacts - coins and pottery of the last quarter of the fourth century. How far into the fifth century there was sufficient urban organisation or population to carry out such work, we have, at present, no means of ascertaining, and the assumption that the silting up of the sewer relates to a bath-house may be wholly unwarranted. The palaeo-environmental evidence, particularly the freshwater mollusca, however, shows that freshwater was flowing at least into channels 5 and, almost certainly, 6 when the final phase of sedimentation was brought to a close, and that freshwater was derived, at some point, directly from a sub-aerial rather than a ground water source, although the movement of ground water at a slightly greater rate than the current one would have been sufficient for the cavernicolous ostracods. The freshwater fauna in the sewer from the terminal phase also need not relate to the presumed baths overflow but could represent detritus derived from temporary diversions of the fortress supply to flush out the sewers, the coarser sediment with some entrapped biological materials remaining on the floor of the channels, materials which could only be removed by sending a man with shovel and bucket down the manhole. If this is the case, it is surprising that the relatively buoyant gastropod shells remain. A size analysis of sediment, particularly from channel 5, may shed further light on this problem

since the resultant graph should be strongly bimodal with a course faction from flushing and a fine from normal flow, if the latter occurred.

Apart from the great numbers of Psychodid pupal fragments, the sample from side passage 3 included the furniture beetle, Anobium punctatum, plaster beetles, Enicmus minutus group (Lathridius spp. of Tozer, 1973) and the golden spider beetle, Niptus hololeucus. Whilst the first occur in outdoor situations and can be regarded as part of the indigenous fauna, Niptus hololeucus, in Northern Europe, is restricted to indoor habitats created by man, although there are records from lime (Tilia spp.) in Sweden (Palm, 1959). It is omnivorous, the imagines often feeding on the debris of other insects, and is not uncommon in bakeries and shops at the present day. It perhaps came down the small chute which drains into the top of this channel from the inside of a building above and, in view of the presence of of seeds of edible plants, there is no reason why the principal function of side passage 3 should not have been as an outlet from a latrine. As elsewhere in the system, the fauna also included a number of vertebrates (Simms & Rackham, 1976). . The wood mouse, Apodemus sylvaticus, often occurs indoors at the present day, particularly in winter, and the shrews, Sorex spp., are active foraging insectivores and may enter outbuildings whilst searching for food. The field vole, Microtus agrestis, could have lived in grass on the backing rampart to the fortress wall, a few metres away from the buildings. These could have entered the sewer through drains in buildings, or could have entered by burrowing, although the substantial nature of the overlying buildings makes this seem unlikely. It should be remembered, however, that many of these animals may have entered whilst the buildings were in decay and little frequented by man. It

is possible that the small fish were introduced down an aqueduct, if the vertebrae do not represent food debris, but the slow worm is more difficult to explain. It may also have lived in long grass on the rampart or have been introduced into the fortress in a cartload of straw, and entered the building fortuitously, attracted by the damp humid atmosphere. Perhaps like the jackdaw and raven (Simms & Rackham, 1976), it could equally well have been a pet or casual human introduction. It is possible that the insectivorous vertebrates, particularly the amphibians, could have introduced insect remains in their stomachs, which could explain the fragmentary nature of most of the non-synanthropous beetles. The small sample of the native wild beetle population could then be wholly of secondary origin, being further selected by the preferences of the foraging vertebrates. Several complete small vertebrate skeletons were noted during excavation, and it is probable that many arrived either by crawling up from the outfall or by the pit-fall traps of the chutes and channels into the system from the buildings above. Allowing this origin for much of the non-synanthropous element in the insect fauna, the closed nature of the system is further emphasised, the appearance of small vertebrates in the overlying buildings, perhaps in decline if still in use, being explained on behavioural grounds. The contrast with the insect fauna recently obtained by Kenward (1975) from a modern street drain in York further emphasises the isolation of the sewer faunas from the natural and synanthropic background faunas of the legionary fortress and its environs.

The fill of the main channel between side passage 3 and the blocking beyond 1 of the main channel (fig93) was of a coarse, poorly sorted sand and gravel with much building debris, bone and pottery,

most of which was considerably earlier than the apparent date of infilling (Sumpter, 1976). It would appear that this material represents a single influx down side passage 1, perhaps whilst there was much spoil at the surface during construction work, or during the insertion of the blocking across the main channel. No attempt was made to clean out this part of the system afterwards, despite the foul pond created in channel 3 by the partial obstruction of its outlet. Some flow down this part of the system, however intermittently, must have continued until the sewer finally went out of use, since joins between sherds of pottery were obtained throughout the system (Sumpter, 1976), and there was some spreading of the gravel which virtually filled the channel at the west end, into the dark grey silt, a few centimetres of which covered the floor east of side passage 6. The main channel appears to have been cleaned out to a point just beyond side passage 6, and it should be noted that a marked division in molluscan faunas occurred here (Cameron, 1976 & fig.96) between a eurytopic assemblage, which could have largely lived in the system, and a eurytopic plus freshwater fauna to the east. This is more probably a factor of the position of the two major lines of baths overflow, channels 6 and 2b (fig.93), which would tend to wash any silt accumulation downstream and keep the channel relatively clear, until the water supply failed or a blockage occurred upstream of the excavated part of the system.

Many specimens of the ant, Ponera punctatissima occurred in side passage 3 and this species was recovered in even greater numbers in side passage 4. This is a doubtfully native species with a rather southern distribution in Europe (Schmiedeknecht, 1930), and in the northern half of Europe it tends to be almost

entirely synanthropic. Accidental transport in commodities has now given it an almost cosmopolitan distribution and it is probable that, together with many species in this list, it owes its first introduction into Britain to Roman trading activities. Infestations have been reported from a variety of man-made habitats, including rubbish tips and houses (Collingwood, 1964), but the description of an infestation in Betteshanger Colliery, Kent, where the miners had complained of being bitten and stung, seems singularly appropriate: "continuously wet and foggy, with condensation water much in evidence... the temperature taken was 25.4°C" (Yarrow, 1967); this could equally well apply to the heated rooms of a Roman bath-house. At Betteshanger the ants were living in wet, rotting timber. A solitary specimen of this ant was also found in a sample from a surface drain in the partially excavated structure with hypocaust over the eastern part of the system (fig.92). It has to be considered whether this individual can be used to provide the much needed link between the stratigraphy of the sewer and the superincumbent buildings. In other words, its viability as a zone fossil has to be discussed. Even in man-made habitats, it is difficult to estimate the longevity of ant populations and, once established in a group of buildings, cushioned from adverse external climatic factors, nests would be virtually impossible to eradicate. After the baths had fallen into disuse in the post-Roman period, the ants could have continued living on the decaying woodwork, as in the Betteshanger Colliery infestation (Yarrow, 1967), until immediately local food sources were exhausted or until the ants were wiped out by a particularly severe series of winters. The example in the surface drain could, therefore, be separated from the numerous specimens in the sewer by over a hundred years, rendering it archaeologically useless for correlation. The York record is the only sub-fossil one for

Ponera punctatissima, and it remains possible that the species is native to Britain and was once more widespread.

From sample 7, taken in the main channel immediately outside the outfall of side passage 4, the insect fauna included two pests of stored products, Cryptolestes, probably ferrugineus, and the saw-toothed grain beetle, Oryzaephilus surinamensis; further down the main channel, beyond the diversion, the grain weevil, Sitophilus granarius, was recovered from the sample (9) beneath the Roman manhole. These form the frequent association of pests in stored grain at the present day and there can be little doubt that grain, probably in some quantity, was stored in the building east of the main channel.

The usual form of Roman granary had a raised floor allowing ventilation (Rickman, 1971), and any drainage was into an external gutter around the structure which also took rainwater from the markedly overhanging roof. The virtual absence of outdoor insect species from the sewer, however, strongly suggests wholly internal drains and grain was perhaps kept in either a general stores building or the fauna represents infestation of supplies for a household, or a century, kept in a store adjacent to the centurion's quarters at the end of a barrack block. On the rather tenuous evidence of finds of burnt grain during the first half of the nineteenth century, it is suggested that a granary lay west of the Minster in St. Leonards Place but there is no more secure evidence. (R.C.H.M., 1962). By analogy with other, better explored legionary fortresses, the area of the Praetentura wherein the sewer lay, south west of the Via Principalis, could have been occupied by tribunes' houses rather than barracks. At both Inchtuthill and Nuess the Via Principalis was fronted by a continuous row of small, open fronted stores buildings (Webster, 1969). In York,

these, if they existed, would lie about 60 m. to the north-east of the excavated part of the sewer, and it is possible that grain would frequently be stored in some of them. These buildings, however, would almost certainly have had drains into a sewer beneath the present line of Petergate. Although the three species are cold hardy (Solomon & Adamson, 1955), the assemblage is unlikely to occur far away from grain, and it is improbable that the insects entered the building so consistently and in such numbers from one of these stores or the as yet unlocated main granaries in the fortress. Both Oryzaephilus surinamensis and Cryptolestes ferrugineus are recorded from natural habitats in the south of England (Hunter et al., 1973), and both are capable of flight. These could actively seek out suitable habitats in the settlement on a greater scale than Sitophilus granarius, which is flightless and tied to grain for its breeding cycle. The occurrence of the former, therefore, need not alone imply stored cereals in the immediate vicinity. The grain weevil may stray from the stored product seeking suitable niches for hibernation but, although there is no quantitative data, it is unlikely to move far. It should be noted, however, that Thomson (1922) records a case in New Zealand where an infested cargo was dumped on the beach close to a town and S. granarius was observed crawling from it in large numbers towards the town.

Downstream from the blockage and realignment of the main channel, a narrow drain (fig.93) joined the main channel to the diversion beyond the blocking, showing that some drainage from the blocked off main alignment still had to be taken into account. It is possible that the rebuilding represents a division of the drainage rather than a partial abandonment, problems perhaps having been encountered with the ponding back of the outflow down the one alignment by a greater flow down another channel, perhaps down the Via Principalis,

necessitating a separate outfall for the baths channel. This drain and the blocked off section of the main channel were allowed to silt up and not cleaned out after c.A.D.200 (Whitwell, 1976). . The fauna from the gravel fill of this section includes grain beetles in the largest numbers found anywhere in the system. The narrow connecting channel, however, whilst containing the general fauna of the system, lacked the grain beetles and it is possible that the initial use of the overlying building may not have included the storage of grain, although little weight can be placed on this evidence since the number of individuals is so low. At the top of the succession, the three species of grain beetle are supplemented by Aglenus bruneus, an eyeless, flightless beetle, not uncommon in the residues of damp grain bins (Woodroffe, 1967) but also known from stables, tanneries, etc. This species was recovered in large numbers from the Anglo-Danish tannery and leather-worker's shop beneath Lloyd's Bank in Pavement, York (Buckland et al., 1974). The flour beetle, Tribolium sp., has previously been recorded from late Roman deposits at Droitwich (Osborne, in press). It is most frequently found in flour but also is associated with a wide range of other stored products (Munro, 1966). It cannot withstand winter temperatures in Britain in unheated premises and only persists by virtue of frequent reintroductions.

In the upper part of the fill of the blocked off section, there was a considerable quantity of comminuted charcoal, which could conceivably relate to the hypocaust installed in the building adjacent to the sewer. Besides the ubiquitous furniture beetle, Anobium punctatum, two species of insect could relate to timber brought in, perhaps to fire the hypocaust. One, Trixagus dermestoides, is not specifically a timber beetle, the larvae living and pupating in the soil (Palm, 1959), although somtimes occurring in rotten timber

(Skidmore, pers. comm.); the imagines, however, are sometimes found in rotten wood and beneath the bark of deciduous trees. The other, the pine weevil, Hylobius abietis, is a common pest in forestry, although its present ubiquity is probably related to the conifer-orientated activities of the Forestry Commission. As its vernacular name suggests, its usual host is pine (Pinus sylvestris), although other conifers may be attacked.(Chrystal, 1937). The beetle could have been brought in with wood to fire the hypocaust. Pine was apparently used to fire the pottery kilns whose waster heaps have been found to the south-east of the fortress (King and Jones, pers. comm.), and it would probably have grown on the sandy heaths of Galtres, east of the city. There has been little analysis of charcoal from hypocausts and it is possible that preference was shown for pine wood since the smoke leaking from poorly jacketed flues in the caldarium would smell somewhat more pleasant.

Conclusions

It might appear that the tenuous thread woven through the palaeo-environmental and archaeological evidence has been lost in a maze of contradictory information. The intention, however, was to explore as fully as possible the differing lines of approach, largely through the biota, to an unusual archaeological environment. It is apparent that, given sufficient topographic parameters and the restrictions imposed by other faunal and floral investigations, a comparatively restricted insect fauna can provide data for the interpretation of an archaeological entity when only a minute fragment is recovered by rescue excavation. The proposed model (fig.96) suggests a wholly closed system for the sewer, taking drainage from within buildings, perhaps including a bath-house, supplied with fresh-

water down an aqueduct. The evidence for human faeces entering the system is substantial if not wholly conclusive. Grain was stored in a building or structures lying to the north-east of the main alignment, perhaps consistently over a period of at least one hundred years, or at least at discrete intervals within this period. The structure was not a granary of the normal Roman pattern.

Whilst considerably better than any model proposed on the purely artifactual material, it must be understood that this is only a model, proposed on a sample of a mosaic of naturally randomly sampled palaeoenvironments. This account differs from the published (Buckland, 1976) in including much more of the interpretative thought which went into the construction. It will remain only partially tested until the Roman buildings served by the system can be entirely excavated. Not only is this impractical in the foreseeable future, but it is probable that some part, particularly the immediately post-Roman, has either not been completely preserved or has been destroyed already. The sewer has provided a few clues for the archaeologists of the future to conjure with, to substantiate or refute.

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"Few people outside government and commercial circles immediately concerned realize the steady tax insects extort from man in his efforts to store and distribute food and other consumable commodities. A survey carried out under the auspices of the United Nations Food and Agriculture Organisation (F.A.O.), in 1947, estimated the annual loss sustained by insect infestation in cereal storage at 8%, excluding losses of grain in farm storage."

Munro (1966).

Insect synanthropy : the archaeological record, a Discussion

Changes in the British beetle fauna, particularly within the last one hundred and fifty years, have recently been reviewed by Hammond (1974). The studies of both Thorne Moor and the York Roman sewer have, however, raised a number of points in connection with species directly or indirectly associated with man and, although most of the environmental data, which has been derived from the insect remains has been dealt with, some further, more general comments on particular species are necessary.

In these days of increasingly stringent food hygiene, import regulations and world wide trading connections, the number of species of animal, particularly insects, which were introduced accidentally by ancient trading activities tends to be underestimated, particularly since there are few contemporary references. Mouffet (1658), unwittingly, records one date for the introduction of south east Asian cockroaches to Britain:

> "In the ship called the Philip (which that noble other Neptune, Sir Francis Drake took laden with spices), there was found a wonderful company of winged moths, but somewhat bigger than ours, softer and of a more swarthy colour."

The accompanying illustrations to this section - 'Of Moths called Blattae' - are of cockroaches, although it is difficult to ascertain which species is referred to, perhaps Periplaneta australasii (L.), with Blatta orientalis, itself an introduction, being Mouffet's native one. Drake captured the San Felip, a Portuguese Eastindiaman, off the Azores in 1587.

Many of the pests of stored products were endemic on all ships,

often in very large numbers until this century. In 1768, during Cook's voyage of discovery to the Southern Hemisphere, the zoologist Sir Joseph Banks wrote in his Journal,

> "Our bread is but indifferent, occasioned by the quantity of vermin that are in it. I have often seen hundreds, nay, thousands, shaken out of a single biscuit. We in the cabin have, however, an easy remedy for this, by baking it in an oven, not too hot, which makes them all walk off; but this cannot be allowed to the ship's people, who must find the taste of these animals very disagreeable, as they everyone taste as strong as mustard, or rather spirits of hartshorn. They are of five kinds, three Tenebrio, one Ptinus, and the Phalangium canchroides; this last, however, is scarce in the common bread but vastly plentiful in white meal biscuits, as long as we had any left."

Not only were stored product species shipped around but also many others were transported accidentally in cargoes and ships' ballast. Lindroth (1957 & 1963) has discussed accidental transportation of insects in some detail and suggested that 14% of the Carabid fauna of Newfoundland arrived in this way, mainly from south-west England in sailing ship ballast. Similarly several species, which now have a virtually world-wide distribution, like Oxytelus rugosus, could have been shipped around in dunnage used to secure cargoes. Despite the leaky and foul nature of the holds and bilges of wooden vessels, the transport of virtually entire plant and animal communities could occur, the penetration of sea water being insufficient to eradicate the more salt sensitive species. The comment of a nineteenth century mariner supports this view:

> "It was not unusual for the captain to do a little practical farming in the hold of his ship by planting out upon the freshly trimmed ballast cabbage, lettuce, spring onions, or any edible root that was likely to thrive in the soil he chanced to carry .... " (Leslie, 1890).

Although the included references refer to the larger ships and longer voyages of the post-mediaeval period, the trade between Britain and

Continental Europe, which probably reached its first major peak during the Roman period would have provided ample opportunity for the introduction of synanthropic insects. Even on coastal voyages, some livestock was frequently taken for provisions, thus providing a further habitat and, in view also of the absence of synthetic packing materials, the occurrence in Roman deposits of species hitherto regarded as recent introductions is therefore not surprising. In the light of this, the examination of the archaeological record of certain species directly or indirectly associated with man is instructive.

Niptus hololeucus

The golden spider beetle is illustrative of how evidence from the sub-fossil record can modify the currently held views of entomologists on particular faunal origins. Hickin (1965) adopts the view of Zacher (1927), that N. hololeucus was introduced from the northern shores of the Black Sea during the first half of the nineteenth century. Zacher went so far as to chronicle its spread in Western Europe most exactly ....

> "It was discovered in 1836 in Asia Minor; in 1837, it was carried among pigs' bristles from southern Russia to Hoxton in England, similarly with rhubarb roots from southern Russia to Dresden in 1840, to Calais 1855, Hamburg 1862, Greiz in Thuringia 1865, between 1860 and 1870 to Sweden, in Wurtenburg first in 1874 and in Bergen and Christiania (Oslo) in Norway in 1875. It has been known in North America since 1899 and, since 1920, has begun to spread strongly."

This apparently detailed account of an expansion by an introduced species first came to be doubted in 1969 when Cymorek and Koch published a note on specimens from a 15 - 16th Century latrine excavated at Neuss in the Central Rhineland. The York sewer examples now place the date of its arrival in England back into the late Roman

period (Buckland, 1976) and, although it must almost certainly be regarded as an introduction in Britain, it, as Cymorek and Koch (1969) note, has to be discussed as possibly native to Central Europe.

Despite its ability to overwinter in unheated buildings (Solomon & Adamson, 1955) and withstand temperatures of at least -8°C (Cymorek & Koch, 1969), the golden spider beetle is very rarely recorded in the open in Britain and the few outdoor captures are regarded as both unusual and directly anthropogenic (Donisthorpe, 1939) (Solomon & Adamson, 1955). In Britain, therefore, it is best regarded as an obligate synanthrope, which, despite its very great catholicity in food, cannot maintain itself in the wild. The larvae are most frequent in granaries (Koch, 1971), and most major infestations stem from corn residues. The imagines, however, are very polyphagous, having a preference for textiles, but occurring in virtually everything from feathers to cocoa powder (Zacher, 1927). As well as in warehouses, the golden spider beetle also occurs in houses and bakeries, although, since it is flightless, its dispersal potential is low, other than by accidental human agency. Its natural habitat would, like many pests of stored products, appear to be birds' nests, although it has also been taken in caves occupied by bats (Koch, 1970), and on lime (Tilia spp.) in Sweden (Palm, 1959). Even in nests, however, Woodroffe (1953) noted a preference for rubbish, such as mortar and rubble, rather than for the actual nest. The possibility of accidental short range transport by birds is apparent from Woodroffe's (1953) record from a jackdaw's nest high upon the roof of Canterbury Cathedral. In archaeological contexts it would appear to be a particularly good indicator of material which has either accumulated within a building or has been removed from one.

If Zacher's (1927) contention that Niptus hololeucus is native to the Black Sea littoral is accepted, its spreading by the agency of man in Western Europe poses a number of interesting problems which can only be solved by further work on sub-fossil deposits. The initial expansion into southern Europe may have taken place during and after the seventh century B.C., when several Greek cities founded colonies in the Black Sea region, particularly in the Crimea. Although there is evidence of earlier contacts during the Mycenaean period - as early as the middle of the second millenium B.C. (Sulimirski, 1970), it is probably the trade in cereals which grew up with these cities and their hinterland which provided the vehicle for the shipment of the golden spider beetle around the Mediterranean basin. Like the other beetles which characterise the grain fauna, discussed below, once into Italy, N. hololeucus would have followed the Roman army across Western Europe in the first centuries B.C. and A.D., an unwanted passenger in the vast quantities of stores required to maintain the Roman military machine. There remain, however, the problems of continuity. The collapse of the western part of the Roman Empire in the fifth century A.D. brought an end to the large scale transhipment and storage of grain and, at least in Britain, a return towards a subsistence based economy with consequent decay of towns. It is not yet clear how much continuity there was in the major urban centres, a problem which, in the absence of artifactual evidence, can probably only be solved by detailed study of the environmental material. The apparent association of the larvae with corn debris and the inability of the imago to overwinter in non-synanthropic habitats mean that the possibilities for the survival of Niptus in the post-Roman period are closely tied up with the problems of urban continuity into the sub-Roman and early Saxon periods. Whilst at least some semblance of continuous human occupation appears more

probable now than ten years ago, it is doubtful whether the species could maintain itself in the many small ephemeral stores of grain of subsistence farmers, although, like the problems of the death watch discussed above (p.247 and Buckland, 1975), the absence of sufficient concrete evidence makes theorising easier. Even if the beetle failed to maintain itself in Britain after the end of the Western Roman Empire because of the virtual disappearance of its man-made insulation against the oceanicity of the climate, it could have survived in the continental climatic regime of the Rhineland to occur in fifteenth century deposits at Neuss (Cymorek & Koch, 1969) and have been reintroduced from thence to England, where it occurred in a mediaeval pit at Exeter (Osborn, pers. comm.). Such introductions - and the Neuss examples could equally be the result of trading contacts with centres further south and east - need not have achieved any degree of permanence and Lacher's thesis (1927) may still be correct. It is surprising, however, that such a relatively common and distinctive insect occasionally occurring in large numbers (op. cit.) should have to wait until 1836 to be described, unless that is the date of its reintroduction into increasingly more suitable synanthropous habitats.

Another Ptinid from the Roman sewer, Tipnus unicolor, whilst occurring in stored products and household situations (Hunter et al., 1973), appears to belong to the native fauna and has been recorded in the wild as far north as Central Scotland in leaf litter and similar habitats (Crowson, 1962).

The Grain Fauna

The characteristic beetle pests of stored grain have now been found in several deposits of the Roman period in England. Cryzaephilus

surinamensis, the saw-toothed grain beetle, and Sitophilus granarius, the grain weevil, were recovered from a mid-second century pit at Alcester, Warwickshire (Osborne, 1971), together with other pests of stored products, Stegobium paniceum, Palorus subdepressus and Tenebrio obscurus. A Tenebrio, probably obscurus, was also recovered from the mid-first century defensive ditch around Verulamium (Bradley, 1958). A late fourth century carbonised grain deposit at Droitwich, Worcestershire, included O. surinamensis, S. granarius and Tribolium castaneum, the rust red flour beetle, (Osborne, 1974 and in press) and a similar layer within the Roman fort at Malton (below p.390) produced the grain weevil and the saw-toothed grain beetle, with Cryptolestes ferrugineus. O. surinamensis occurred in the late fourth century filling to a well at the Roman villa in Barnsley Park, Gloucestershire (Coope & Osborne, 1967) and this species has also been found in Roman deposits at Neuss in Germany (Koch, 1971). The grain fauna occurs in the Roman sewer at York (above p.354). For these species, the earliest British records are Roman; the other meal-worm beetle, Tenebrio molitor, is first recorded from an Anglo-Danish site of the tenth or eleventh century in York (Buckland et al., 1974). Another Tenebrionid, a cellar beetle, Blaps lethifera, was recovered earlier this century from Roman deposits in Caerwent and possibly also from Silchester (Amsden & Boon, 1975). This now rare insect, found in cellars, outbuildings and granaries and occasionally imported, has only been recorded once since c. 1900 (Brendell, 1975). There is some doubt about the earliest find of the small, eyeless, flightless Colydiid beetle Adelenus brunneus, which occurs, among other habitats, in sour grain residues. Three examples occurred in sample 12 from the Roman sewer beneath York (above p.356) but, since this layer had been partially disturbed by a rat burrow and yielded a mandible of the brown rat, not introduced until the post-mediaeval period (Corbet, 1974), one has to acknowledge Kenward's (1975) doubts about their contemporaneity. It

was, however, well established in York by the tenth century (op. cit. & Buckland et al., 1974) and the preservation of the sewer examples was that of the contemporary fauna rather than a contaminant.

Two of these species, O. surinamensis and C. ferrugineus have been recorded in the open in non-synanthropic habitats in England, the former 'at fungus' (Joy, 1932) and the latter under bark (Donisthorpe, 1939). It is possible, therefore, that the specimen of C. (?) ferrugineus from Fishbourne in Hampshire (Osborne, 1971) derives from a natural habitat, although, since it was recovered from the silts of a Roman harbour, a synanthropic source seems probable. This example, from a layer,dated to the first century A.D. (Cunliffe, 1971), and the Tenebrio sp. from St. Albans are the earliest representatives of the pests of stored products so far recovered from Britain. In the Mediterranean region, however, the association of certain species with man can be traced further back; both S. granarius and O. surinamensis were recovered from a baker's shop in Herculaneum, destroyed when Vesuvius erupted in A.D. 79 (Dal Monte, 1956) and, with products placed in an alabaster vase as an offering in the tomb of Tutankhamen, c.1350 B.C., were Lasioderma serricorne, Stegobium paniceum and Gibbium psylliodes (Alfieré, 1931). A specimen of Tribolium, either confusum or castaneum, occurred in a tomb of the VI Dynasty (c. 2,500 B.C.) in Egypt (Andres, 1931) and this remains the earliest association between a synanthropic insect and man.

The discussion of the spread of those species closely associated with stored products is beset by the same problems as Niptus hololeucus and the conclusions reached are very similar. Since O. surinamensis and C. ferrugineus are capable of active, if limited flight,

with available natural habitats in Britain, they could, like the death-watch discussed in more detail elsewhere (Buckland, 1975 & p.247), belong to the Urwaldrelikt fauna and have once, in a period of greater expanse of suitable forest habitats and moderately warmer temperatures, been able to colonise synanthropic situations from the wild, a view apparently held by Horion (1960). Conversely it is equally possible that the few recent outdoor records (Hunter et al., 1973) are secondary and that these two species are Roman and later introductions, Unlike the death watch, there is greater apparent contrast between the records of their natural habitats and their anthropogenic findspots. Neither, however, is specifically tied to the stored product and the apparent disparity probably hides a close similarity in micro-climates. The problem of whether these species are a natural part of the British fauna or are Roman or earlier introductions can only be solved by their occurrence in pre-Roman deposits wholly divorced from human habitations, although care has to be taken in interpretation, since O. surinamensis actively colonised birds' nests on a farm (Woodroffe, 1953) and could easily occur in apparently naturally accumulated deposits close to an unlocated archaeological site; in the present state of our knowledge, absence cannot be considered evidence. As there are records of O. surinamensis in the wild elsewhere in Europe (e.g. Horion, 1960), there is no reason to consider the suggestion of Amsden and Boon (1975) that the beetle may have arrived during the Roman period from the East with imported rice. Although both rice and this insect are recorded from Roman deposits in Neuss, the saw-toothed grain beetle is a fairly generalised pest of stored products occurring in products derived from grain, dried fruit, nuts and rice (Horion, 1960). There is no evidence therefore to regard rice as its primary habitat. Once introduced, however, both could survive the post-Roman curtailment of suitable

large scale man-maintained habitats in their natural pabula, provided that climatic and human interference factors remained constant. The dark mealworm beetle Tenebrio obscurus could equally belong to this group, although Solomon and Adamson (1955) suggest that it has been introduced from a warmer climate and it is uncommon even in synanthropic habitats in this country. Both T. obscurus and T. molitor are recorded from rot-holes in deciduous timber in Central Europe and Palm (1959) considers this their primary habitat, although they are also known from birds' nests. T. molitor sometimes occurs in great numbers in pigeons' nests (Brendell, 1975), a habitat from whence they could more easily invade buildings. The mealworm beetles are good fliers and tend to be attracted to light. Their occurrence in small numbers in archaeological deposits has therefore to be treated with some circumspection, although the presence of the less well sclerotized larval head capsules is clearly more indicative of a suitable palaeoenvironment.

The species of Tribolium pose similar, if more complex problems. The flour beetles are unable to overwinter in Britain in unheated premises (Solomon & Adamson, 1955) and are virtually unknown from natural situations in this country. The areas of origin of these now cosmopolitan species have yet to be satisfactorily defined. Brendell (1975) follows Hinton (1948) in suggesting that T. confusum and T. destructor are of African extraction and T. castaneum is Indian. On the basis of the apparent phylogeny of the genus, Hinton (op. cit.) further suggests that the Tribolium recovered from an Egyptian tomb of the mid-third millenium B.C. (Andres, 1935) must have been T. confusum, since the alternative, T. castaneum, could not have been introduced from India at this early date. This thesis, however, grossly underestimates the extent of coastal trade around the Arabian Sea and the Persian Gulf, during the Chalcolithic and Early Bronze Age. The huge

granaries excavated at Harappa and Mohenjo-dara in the Indus Valley (Wheeler, 1966) would have provided ideal synanthropic habitats for several pests of stored products and there is good evidence for trading contacts with the civilisations of the Tigris and Euphrates valleys and thence, by way of either Syria and the Eastern Mediterranean littoral or the Red Sea and Gulf of Suez to Egypt. It should not be thought that flour or cereals were the items of trade but each ship would carry sufficient victuals for the voyage and emergencies, and there is some evidence for intermediate supply depots along the coasts of present day Pakistan and Persia, which would require provisioning (op. cit.). Any synanthropic species in this region could therefore have become cosmopolitan in the Ancient World by the third millenium B.C. Despite the present lack of fossil evidence, Bahrein (?Dilmun) (Bibby, 1970) would have been as much an entrepot for the Old World pests of stored products as it was for trade. If Parise' (1966) suggestion of a common system of weights throughout the ancient civilisations of the East is accepted, the extent of this early trade would appear considerable. Kaszab (Freude, Harde & Lohse, 1969), however, has suggested that T. destructor and, presumably, the other member of the sub-genus Stem which occurs commonly in Europe, T. confusum, are of South American extraction. If this is accepted, Andres' specimen has to be T. castaneum. Accepting Hinton's phylogeny, and suggested paucity of trading contacts between the Indian subcontinent and Egypt, it is surprising that T. castaneum has been definitely identified from Roman deposits in Britain (Osborne, 1974). By the Roman period, however, there were considerable trading links with India (Wheeler, 1954) and its spread into the Western Mediterranean would have been accomplished by way of the extensive corn trade between Alexandria and Rome. The journey across Western Europe would have been aided by the munitions service which supported the Roman army in

the first centuries B.C. and A.D. In Britain, T. castaneum has once been observed breeding in, and flying from a poultry house manure heap in Somerset (Jones, 1967) and, although the source in this case is clearly anthropocnorous, it does show that a certain amount of caution is necessary when interpreting single individuals in archaeological assemblages. In Central Europe, T. madens is recorded in the wild from powdery, rotted old deciduous timber and it is possible that both this species and T. castaneum were, like certain other forest species discussed above (p.221), once part of the British fauna. T. madens, however, is so rarely imported into this country with stored products today that it is omitted from the most recent key to the British Tenebrionidae (Brendell, 1975).

While the species so far discussed could have been part of the native insect fauna of Britain in a period of greater extension of suitable forest habitats and slightly more continental climate, the grain weevil, Sitophilus granarius (L.), could not, since it is tied to crops cultivated and stored by man. It has been recorded from a wide range of products, including corn, rye, barley, maize, oats, buckwheat, millet, chickpeas and, more rarely, in chestnuts, acorns and corn-meal (Hoffman, 1954). The principal habitat, however, is stored cereal crops, where the larvae develop wholly within the grains. Both O. surinamensis and C. ferrugineus occur largely as secondary pests in grain affected by weevil attack, The species would appear to be relatively cold hardy (Solomon & Adamson, 1955) but the atrophosis of the wings means that it is completely dependent upon accidental transport by man for its dispersal. Despite this apparent drawback, S. granarius is now fully cosmopolitan and, with the rice weevils S. oryzae (L.) and S. zeamais (Mots.), this genus forms the most serious

group of primary pests of foodstuffs at the present day. In the more developed countries, the widespread use of insecticides has somewhat curtailed their activities but in less advanced societies, where the only effective means of eradication is burning, the grain and rice weevils can be as much instruments of famine as drought or flood. In France, before the last war, 5% of corn produced was destroyed by grain weevils (Hoffman, 1954) and the 10% loss of world cereal production by insect infestation estimated in 1947 by the United Nations Food and Agriculture Organisation(Munro, 1966) probably more nearly approaches that of a pre-industrialised society but would still be a considerable underestimate. This continual running factor of losses during storage has been ignored in calculations of necessary cereal production in prehistoric and protohistoric societies. Figures, such as those of Manning (1975) for grain requirements for the Roman army in Britain in the late second century, must therefore be considerably below the actual, particularly since losses would have been proportionately greater in the larger granaries of forts than in the smaller native settlements. Continual reinfestation from residues in the building, still a major problem today (Coombs & Freeman, 1955), would have been unavoidable in the permanent forts and total spoilage, as has been suggested for the Malton grain (below p.390), could not have been rare. Since S. granarius is recorded from several Roman sites, other than military establishments, where importation from the Continent is possible, including a villa (Bey's Meadow, Droitwich (Osborne, 1974)) and a small town (Alcester (Osborne, 1971)), spoilage of stored cereals on both the local and centralised level was probably considerable within the Roman period and, allowing for further losses caused by damp and toxic microflora, an additional factor probably well in excess of 10% has to be allowed between

production and consumption; this clearly has some influence on estimates of population of individual sites based upon the archaeological record and upon any attempt to consider land utilisation and population. The pests of stored products, particularly the grain weevil, add another complex and imponderable factor to any palaeoeconomic study.

The existence of S. granarius in the pre-Roman period in Britain has yet to be proven , although it should be remembered that particularly suitable deposits have so far only been examined on the Middle Bronze Age site of Skara Brae (Buckland, unpubl.) and from the Iron Age hillfort at Danebury (Osborne, unpubl.). Reynolds (1974) in his experiments into Iron Age grain storage has chosen to ignore the possible effects of weevil attack although the method of storage examined, clay sealed pits, would have been lethal to weevils after a relatively short period of time as a result of the increasing concentration of carbon dioxide, an effect examined in modern storage pits by Dendy and Elkington (1920). As Manning (1975) has pointed out, pit storage was, however, by no means universal even in the South-East of England and other methods of grain storage must have been practised, particularly in the Highland Zone where such pits are absent. Other methods of storage would have been more amenable to the grain weevil and the large numbers of 'four-poster' structures on some Iron Age sites could as much reflect the frequency of ineradicable infestation as other factors, although it has to be emphasised that all 'four-posters' need not be granaries(Ritchie, 1971). Whilst the parching of spelt was a necessary preliminary to threshing (Helbaek, 1952), the relatively frequent occurrence of carbonised remains of other cereals could result from the use of parching to reduce insect damage to corn intended for consumption. In the absence of a fossil record and

evidence for large granaries, it is difficult to assess the importance of S. granarius in a pre-Roman context in Britain. Although able to overwinter in unheated buildings (Solomon & Adamson, 1955), the smaller the amount stored and the less permanent the store, the less likely would the insect be to maintain itself on any sort of a permanent footing. Although it may have arrived with the seed corn of the flint Neolithic colonists, on present evidence, both fossil and archaeological, the grain weevil could only have obtained a firm footing with the large granaries and large scale importations of the Roman conquest. If, as the small amount of evidence available would suggest, the grain fauna is largely a Roman introduction, the increase in land under cultivation, which is usually assumed, if not proven, to be an effect of the Pax Romana (e.g. Applebaum, 1972), could be not the result of peace and greater taxation but a consequence of much greater losses to pest infestation during storage, a factor accentuated in the lowlands by the decline in the use of pits for storage. Continuity, through into the mediaeval period, when there are contemporary references (below p.392), remains a problem but one would dearly like to know what fauna the Alexandrine corn ship which docked at Exeter in the sixth century (Frere, 1966) contained.

In Continental Europe the problems are somewhat different and perhaps more complex. Knörzer's (1970) record of rice, almost certainly imported, from Roman deposits at Neuss in the Rhineland raises the possibility of a temporary introduction of Sitophilus oryzae and S. zeamais, the rice weevils. It is possible that attempts were made to cultivate this cereal in suitable localities in the Mediterranean region, although there is no reference in Classical sources and it apparently was not grown in Egypt, where the Nile Delta

provides ideal localities, until Islamic times (Dixon, 1969). On the eastern fringes of the Roman Empire, however, rice cultivation beyond the Tigris and Euphrates was noted in the Hellenistic period (Adams, 1966) and it is possible that a soldier or notary, recruited from the most easterly provinces, brought part of his staple to the Rhineland. In all events, the lack of suitable permanent habitats would have rapidly curtailed any introduced pests but the possibility of ephemeral populations of the rice weevils in Europe during the Roman period has to be remembered when identifying species of this genus.

Accepting the tenet that S. granarius has not made a slight physiological adaption from some other primary host plant to enable it to exploit stored grain as a food source, the grain weevils' initial area of distribution must either coincide with or fall within that of the wild progenitors of the cultivated cereal grasses. The present, maximum extent of wild wheat and barley stretches in a broad arc from the west coast of Anatolia, across northern Syria to Iran and down the Zagros Mountains as far as northern Afghanistan, with an extension southwards through the Lebanon into Israel. One of the two species which hybridise to form the bread wheat, the goat-faced grass, Aegilops squarrosa has a more easterly distribution, stretching from the southern shores of the Caspian Sea eastwards to Kashmir and Khagakistan (Zohary, 1969). As Jarman (1972) notes, however, present distributions may differ considerably from the immediately post-Glacial, when cereal cultivation began. It is not known which of the several species S. granarius occurs on but the cereal grasses can form relatively pure stands over large areas in the park-forest belt of the Fertile Crescent. This zone covers a wide range of variation in climate, characterised by dry summers, and it is therefore not surprising that this weevil has been found to be relatively cold hardy. It might, indeed, at first

seem a little curious that the beetle has not become a pest of standing cereal crops, particularly in those areas of the world which have a similar range of climate. It is apparent, however, that selection by man, accidental or otherwise, for plants lacking a brittle rachis has precluded the spread of the weevil with the crop in the fields. S. granarius must exist in the wild on the many thousand seeds set naturally by this effective dispersal mechanism, although it should be noted that, in the Tropics, the rice weevils attack the crops in the field shortly before harvesting (Munro, 1966). Harlan (1967) was, however, apparently not familiar with it as a problem in harvesting wild wheat. Whilst the suggestion must be regarded as highly speculative, perhaps the grain weevil is with us as a result of over-efficient gleaning of wild crops in the ancient Near East

Conclusion

It is self-evident that the foregoing discussion has been restricted almost entirely to the Coleoptera. This is a factor which is influenced as much by difficulties in identification as by preservation. The Lepidoptera include the next most important pests of stored products to the beetles. The Angoumois grain moth, Sitotroga cerealella (Ol.), occurred in France in the mid-eighteenth century on such a destructive scale that it caused widespread famine (Munro, 1966) yet the chance of recording earlier infestations from the fossil evidence is slight. The adult moth is wholly soft bodied and only the lightly sclerotized head capsules of the caterpillars and the chrysalises could survive in an archaeological deposit, usually in fragmentary form and these have yet to be recognised. The identification of a chrysalis of the garden tiger moth, Arctia caja L., from a Roman ditch at St. Albans (Bradley, 1958), however, shows

that identifiable remains of Lepidoptera can survive. Identifiable fragments of Diptera, particularly Nematocera, where the wing venation imprinted on the pupae can be of specific importance (above, p.333 & fig.95), often outnumber the Coleoptera but these are only of secondary importance in stored products as predators and scavengers. Amongst the Hymenoptera, the ant Hypoponera punctatissima has been discussed above (p.352) from the Roman sewer in York but the other species perhaps to be expected, Pharaoh's ant, Monomorium pharaoris, has yet to be found. These are relatively unimportant pests at the present day, although their status may have changed. Parasitic Hymenoptera of many species are freguent in stores but the chances of identification from fossil fragments, usually the heads of adults, particularly braconid wasps, is slight. The other group of arthropods associated with stored products, the mites, have been less researched but are common in archaeological deposits and the distinctive flour mite, Acarus siro L., should be recognisable. Four species of mite were noted in the St. Albans deposit (op. cit.) and an oribatid mite fauna has been published from post-glacial deposits in Finland (Karppinen & Koponen, 1973, 1974). A study of the few species occurring in fossil synanthropic habitats is therefore feasible.

In part, the paucity of data on the insects associated with man is a result of the techniques used for the recovery of plant remains. Flotation techniques designed for the large scale processing of sediments, the so-called seed machines (e.g. Jarman et al., 1972), may appear efficient in separating off carbonised plant remains but they fail to recover any concomitant fauna, which, in terms of the reasons for the material being destroyed in the first place, may be of considerably greater significance on some sites. The importance of one such burnt grain deposit, that from the Roman fort at Malton, Yorkshire, and its historical implications are discussed below.

"The archaeologist must count himself the luckier when literature can inform him of standards contemporary with his material. The waters are then less perilous, there is less room for erroneous navigation; above all, there is safety from that temptation, of which the effects are visible and were notorious in certain phases of archaeological study, where, failing the resources of thought contemporary with the material from which to infuse it with life, ideas are imported from present day experience and ancient man is anachronistically saddled with views which he would have found at best strangely unfamiliar and at worst grossly distasteful."

Richmond (1950)

The Malton Burnt Grain : A Cautionary Note on A.D.296

To anyone approaching the study of Roman Britain from another discipline, perhaps its most apparent aspect is the marked traditionalism in interpretation, best evinced in the concept of Periods I - IV on Hadrian's Wall. The conviction that "destruction deposits" on the Wall could be closely related to the meagre historical record and the deductions which were made from it developed during the late nineteenth and early twentieth centuries, and received rough dates from Craster's study of the coins from the Poltross Burn milecastle (1911). What began as a rough division between periods of probable rebuilding, with the finding of the Birdoswald inscriptions (Richmond, Birley & Simpson, 1930), became fossilised with the dates and presumed events of 197, 296 and 367, with their corollary of barbarian sack followed by rebuilding (Birley, 1931). The events of 296 in the North are not attested by any contemporary source and what began as an assumption, perhaps a reasonable inference, has become an accepted fact, rarely questioned. Once established, the conviction that the events could be easily traced in the archaeological record spread southwards to areas far outside the hinterland of the Wall, and the legionary fortresses of both York and Chester fell victim to 296 on the slightest of evidence (Miller, 1925; Richmond & Webster, 1951). Richmond, very much the Mephistophiles of the Birdoswald interpretation, dominated Romano-British studies for over two decades and he was thoroughly convinced of the rather simplistic view that burning and/or rebuilding must relate to enemy action, provided that the artifactual evidence tended to imply a date around that deduced from historical sources. In 1958, he wrote,

> "On this occasion also the damage went deep: a century before the legionary fortress at York had fallen, but this time Chester was also taken and had to be largely rebuilt, together with the forts of northern England, the Wall and its outposts"

and he maintains a similar position in his discussion of York and Chester in his revision of Collingwood (1969). Frere (1967), whilst accepting the traditional interpretation in his main text, allows the possibility of rebuilding after a period of decay in a footnote - "quod erat humo copertum et in labem conlapsum" in the words of the Birdoswald inscription (C.I.L.). It is, however, the theme of wholesale destruction followed by counterattack and rebuilding which appeals to the popular imagination and it is this, accepted uncritically, that has become enshrined in the more general literature:-

> "Brushing aside the Foederati of the Lowlands, the Caledonii and Maeatae swarmed down on Hadrian's barrier, crossed it without hindrance, and swept south. At the same time, more perhaps from chance than by collusion, the Irish sea-raiders descended in force on the west coast. The great legionary fortresses at Chester and York were both taken with as much destruction as stone walls and buildings permitted. All through the north as far as York, and in the west through Cumberland, Westmoreland, Lancashire, Cheshire and North Wales, farms, villages and small forts were ravaged and destroyed with heavy loss of life and property. It was a major disaster to Roman Britain." (Welsh, 1965; more recently, c.f. Garlick, 1970).

The actual excavated evidence for "destruction deposits" on the Wall has recently been critically discussed by Breeze and Dobson (1972) and Wilkes (1966) had previously doubted whether there was any great destruction along the Wall at the end of the third century, although his argument that the same units continue in garrison is usually countered by suggesting that they were absent in the south opposing Constantius at the critical juncture (Frere, 1967). A detailed review and more critical assessment of the evidence from sites further south is necessary before a more balanced appreciation of the presumed history of the late third and early fourth century can be attempted. It should be further noted that the basic dating of much Romano-British coarse pottery relies considerably on the concept

of Wall Periods and there are many pitfalls and circular arguments in the cardhouse so constructed.

From this somewhat sceptical viewpoint, borne of destruction which defied conventional chronology and an inability to identify historically attested similar events in mediaeval towns, it was decided to re-examine the extensive burnt grain deposit excavated by Corder (1930) in the Roman fort at Malton, East Yorkshire.

The Malton Burnt Grain

Within the fort, the "carbonised wheat layer" lay along the back of the north-east rampart. In places up to 30cm. thick (op. cit. pl.33), the deposit consisted almost entirely of carbonised grain with a few fragments of similarly burnt timber and covered an area nearly 9m. wide from the back of the rampart, extending northwards for at least 50m. from the north-east gate. To the excavators only one interpretation of such an expanse of burnt grain was possible:

> "Such a layer could not be produced merely by the burning of a granary and a spreading of the debris. It could only be produced by the deliberate destruction of grain stacked systematically along the back of the rampart and there burnt"

a reasonable interpretation of the evidence, but he continues,

> "this layer represents then an evacuation of the fort and its dating is important."

It is unfortunate therefore that the group of pottery figured (op.cit. & fig.99)contains little which can be regarded as chronologically distinctive and is dominated by the very conservative products of local kilns, particularly the calcite gritted jars from the Knapton potteries (Corder, 1932). Corder tentatively places the group in the first half of the third century, clearly regarding it as almost wholly residual in this context, although the published group contains finds

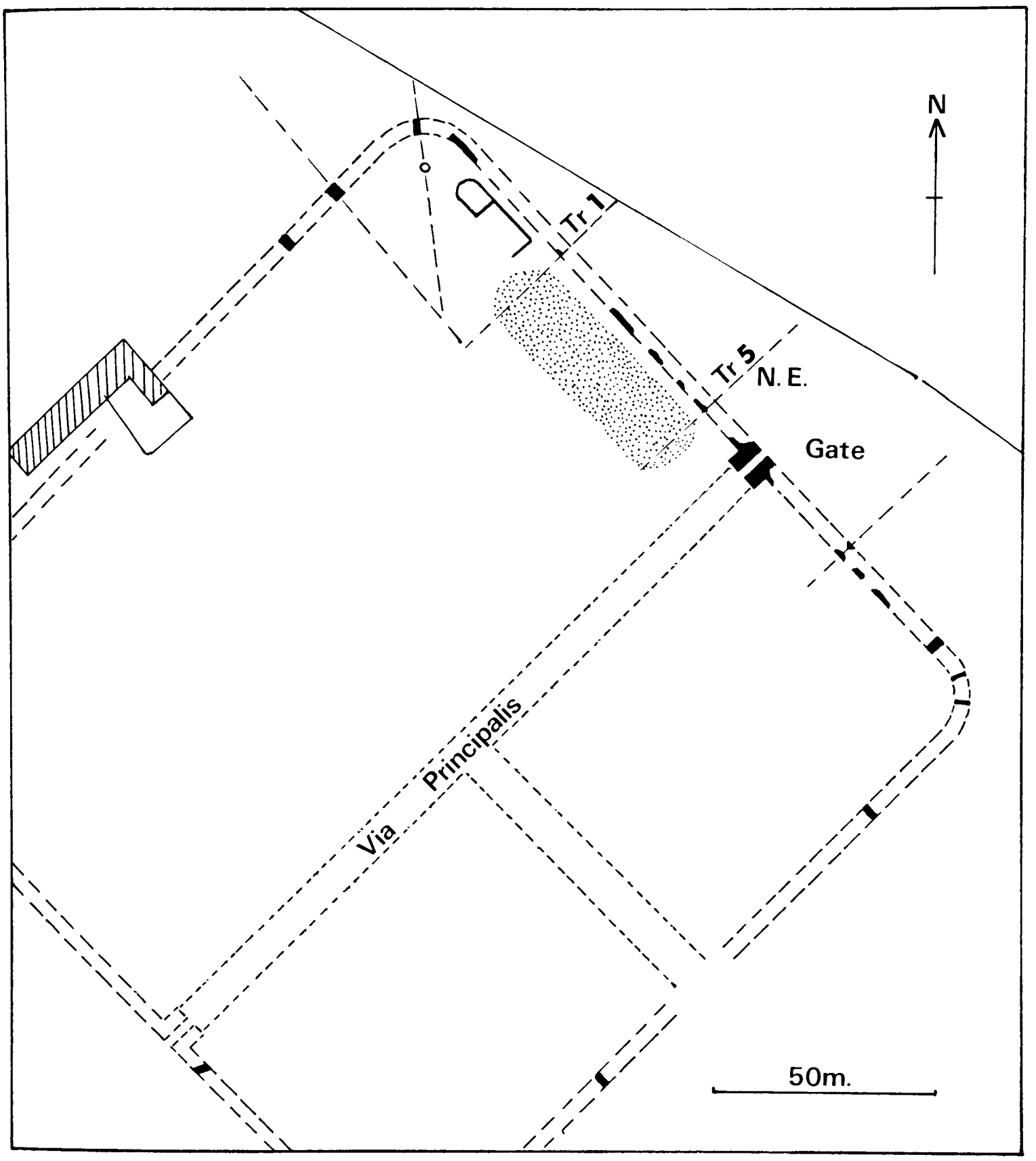
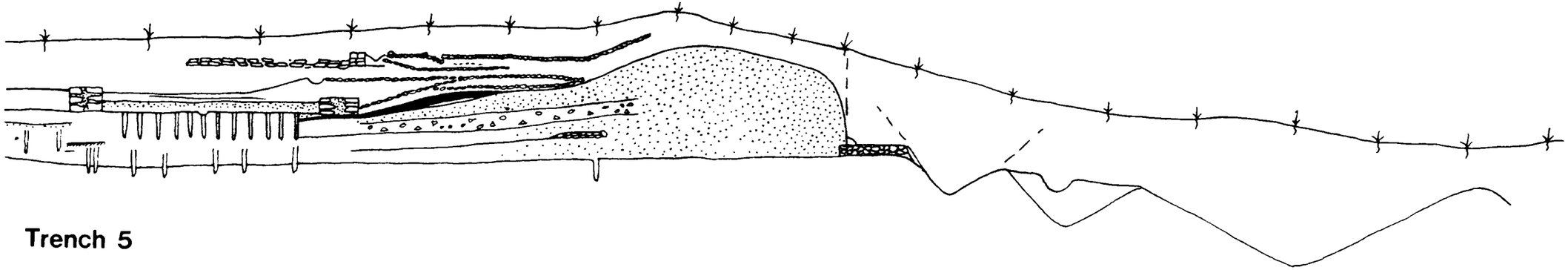


Figure 97. Malton : plan of Roman fort, with location of Corder's trenches and approximate extent of burnt grain deposit (stippled).

from associated layers rather than solely from the wheat. In view of the nature of the deposit, it would seem most unlikely that any vessel would be contemporary with the burning, most perhaps relating to the old ground surface below the burnt wheat; the near absence of complete profiles of vessels would support this view. A terminus post quem is provided by the presence of straight sided flanged bowls in the deposit, a form which seems to have developed initially during the latter part of the second century (Gillam, 1973). The "upper post-hole house", regarded by the excavators as contemporary with the wheat, sealed coins of Antoninus Pius and Caracalla in its floor, further support for a date at least close to the end of the second century or later. Over much of the area the burnt wheat was not sealed by any recognised layer above, although the preservation would suggest that it had been covered not long after burning such that it was protected from destruction by natural processes; the grain was probably sealed by structures since lost to the plough, although it was in excess of a metre below present ground level and the excavators may have failed to recognise or been unable to interpret the irregular traces of later buildings, a common error to the present day . South-westwards from the rampart, the wheat was overlain by a stone building, dated "certainly not earlier than the beginning of the fourth century", although the evidence for this is not provided in the report, and other stone structures, not described, are referred to subsequent to the burnt wheat in the northern corner of the fort. Roads 3 and 4, remetallings of the fort's intervallum road, lie directly over the burnt wheat. The lowest, Road 4, "produced nothing notable" but sealed beneath the upper were coins of Severus Alexander (222-235) and Gallienus (253-268) and one of Tetricus (270-273) lay on its surface. The pottery group is again not particularly helpful (op. cit. fig.99)

Trench 1



Trench 5

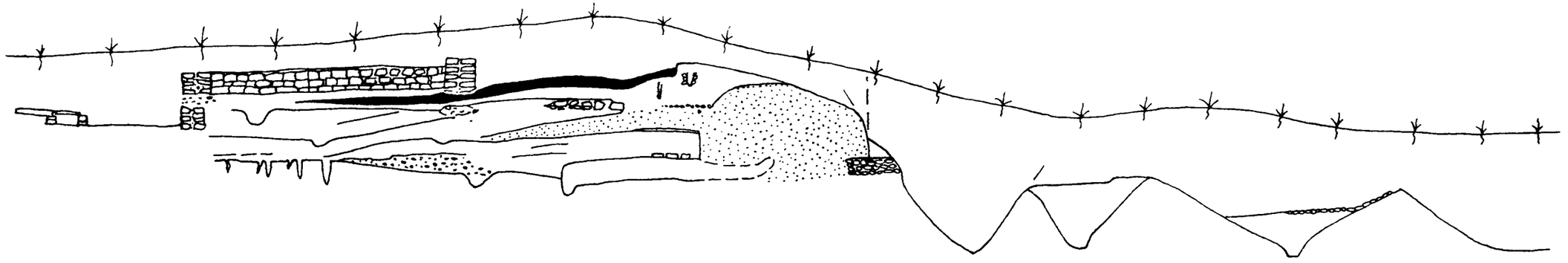


Figure 98. Malton : sections through the northeastern defences showing (black) the burnt grain deposit (after Corder, 1930).

Figure 99. Pottery from the Carbonized Wheat Layer (after Corder, 1930).

1. 'Jar, hard grey ware, lip and shoulder polished, scored oblique lines. A very common type at Malton in the upper layers. Not on Antonine Wall or at Scarborough, therefore 180 - 370.' (!)
2. 'Straight-sided bowl, fine hard grey clay, smoothed, scored intersecting arcs on outside. Diam. over 10".'
3. 'Stout, slightly curved rim of bowl, good drab-grey clay, burnished. Diam. 9".'
4. 'Mortarium rim, white clay, buff exterior surface. Diam. c.12".'
5. 'Rim of a hand-made calcite-gritted jar. Diam. c.6".'
6. 'Rim of calcite-gritted ware, ?wheelmade. Diam. 6".'
7. 'Rim, very coarse grey ware, not smoothed. Diam. 6".'
8. 'Top of small jar, good grey clay, black polished exterior. From 'Upper posthole house'.' (Form should be second century).
9. 'Rim and shoulder of calcite-gritted cooking pot, handmade and very irregular; 7 other examples.' With 5 & 6, these are products of the Knapton, near Malton, kilns excavated by Corder (1932).
10. 'Flanged bowl in cooking-pot ware. Diam. 7". Scored intersecting arcs outside.' c.f. Gillam (1970) type 228, 290 - 370.
11. 'Rim of bowl, fine grey, polished. Diam. c.8".'
12. 'Rim of jar in very hard grey ware, polished outside. Diam. 4".'
13. 'Rim of jar, fine grey ware, polished outside. Diam. 2".'
14. 'Jar, hard grey, polished exterior, save a band containing a wavy line on shoulder. Similar to 1 but unusual.'
15. 'Rim of bowl, coarse dirty grey clay, black exterior, rough and sooted outside.'
16. 'Rim of large jar' Knapton Ware.
17. 'Rim, poor grey ware, sooty. Diam. 5¾".'
18. As 16.
19. 'Rim of bowl, cooking-pot ware. Diam. 7". Scored intersecting arcs externally.'c.f. Gillam (1970) type 227, 210 - 300.
20. '3 rims, 2 plain, 1 scored with intersecting arcs.'
21. 'Rim of bowl, fine grey, fumed light grey.'
22. '3 fragments of small face vase. Red clay, decorated with deeply incised circles around face and on rim. Band above face painted white. Diam. c.2½".'

Figure 99 continued

23. 'Rim of wide-mouthed bowl, fine hard grey clay, fumed black.'
24. 'As 16.
25. 'Hard light grey dish, smoothed. Diam. 6".'
26. 'Hard grey, polished.'
27. 'Hand made dish in calcite-gritted ware, similar to 24. Diam. c. 7".
28. 'Grey, fumed black and polished. Diam. 10".'
29. 'Straight sided dish in similar ware. Diam. 8".'

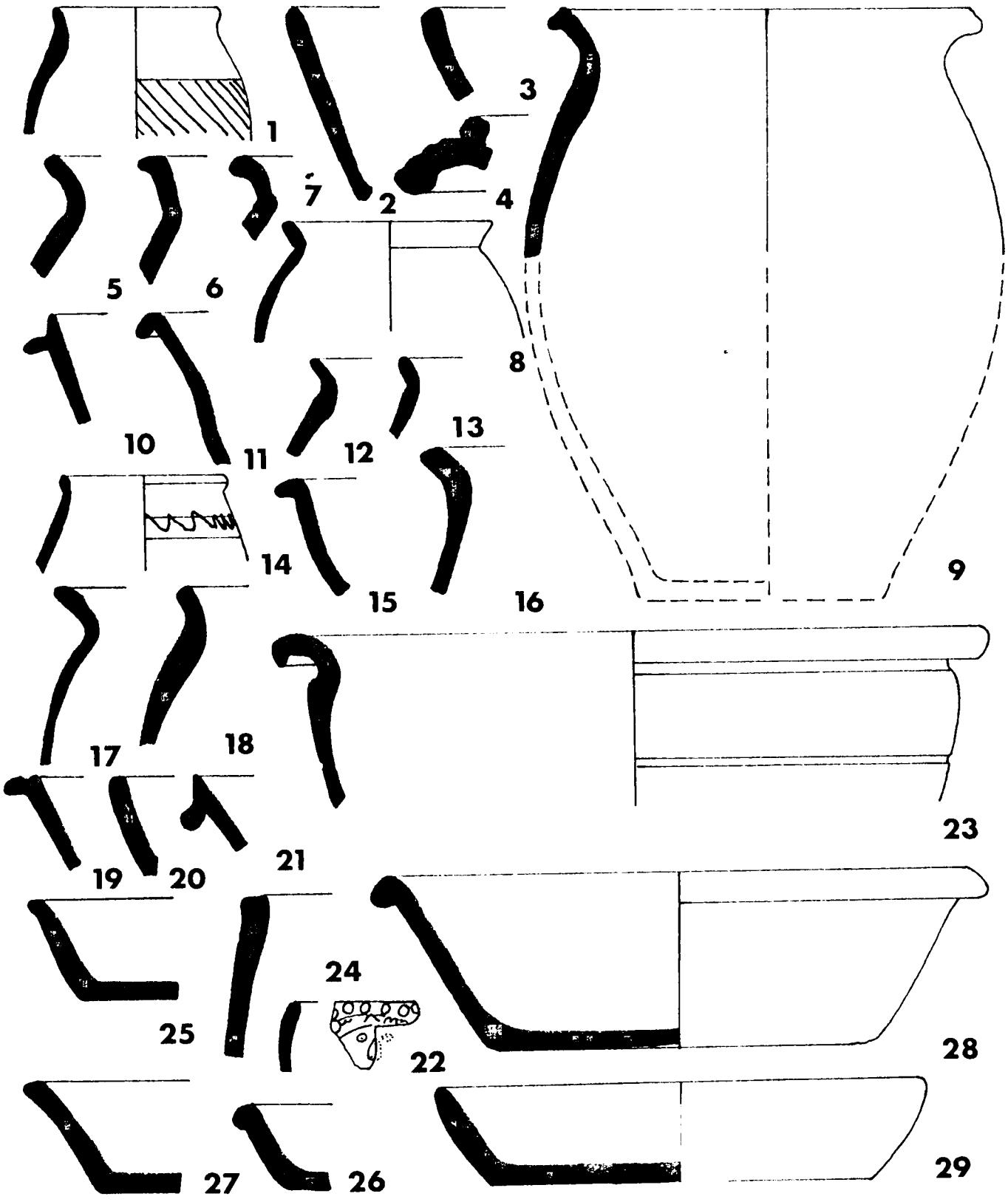


Figure 99. Malton : pottery from the burnt wheat deposit (after Corder, 1930)

but a date within the first half of the fourth century, when the wholly hand-made 'Knapton' jars had been replaced by jars with wheel turned rims, approaching the 'Huntcliff type' (Corder, 1932), would seem probable. Although a pre-Constantinian date would appear more probable, the burning of the grain therefore took place within the broad limits of A.D. 190-350 and, if we are to seek a military cause, a choice of historically attested periods of unrest offers itself - 197-211, 273, 283-285, 296-305 and 343 (Breeze & Dobson, 1972). Corder, however, perhaps influenced by workers on Hadrian's Wall and Miller's (1925, 1928) view of the York evidence, suggested a late third century date for the presumed destruction and temporary abandonment of Malton, an interpretation which has become enshrined in the popular literature (c.f. Longworth, 1965).

The Re-examination of the burnt grain

It is fortunate that Corder realised the importance of the carbonised grain outside his own interpretation and about 20kg. of it passed to the Roman Malton Museum. Jessen and Helbaek (1944) examined a sample of this and found it to be dominated by "various wheats" (300 grains) with subsidiary amounts of clubwheat (11), emmer (12), naked barley (14) and oats (5). Osborne (in press), working with material from the Roman villa at Droitwich, Worcestershire, had already shown that the associated insect pests of stored products could be preserved in burnt grain, and it was decided to examine some of the Malton material from the same point of view. A 5kg. sample of the grain was carefully washed over a 300 micron sieve to remove the fine carbon and silt. Paraffin (kerosene) flotation (Coope & Osborne, 1967) failed to produce a clear separation between any insect remains and

burnt grain and all the material had to be sorted under the binocular microscope. It was apparent that the grain had suffered considerably from numerous cursory and scientific examinations, probably since its initial deposition in the Museum. Many of the grains were broken and it was impossible to make any attempt to assess the amount of insect damage the corn may have suffered. Careful sorting, however, revealed numbers of legs and fragments of thoraces and elytra of three of the principal pests of stored grain. As discussed above (p.371), the grain weevil, Sitophilus granarius (L.) is virtually restricted to stored cereals and, a flightless beetle which could have difficulty in overwintering in Britain in non-synanthropous habitats, its presence in the carbonised wheat layer must be a result of accidental introduction by man, almost certainly with transported grain. The other two species, the saw-toothed grain beetle, Oryzaephilus surinamensis (L.), and Laemophloeus (Cryptolestes) prob. ferrugineus still occur rarely in natural habitats in the south of England (above, p.367& Hunter et al., 1973) but owe their present cosmopolitan distribution to their ability to exploit the artificially 'cushioned' habitats created by man. This fauna, all or in part, has also been recorded from Roman deposits at Droitwich, Worcestershire, (Osborne, in press), Alcester, Warwickshire, (Osborne, 1971), Barnsley Park, Gloucestershire, (Coope & Osborne, 1967) and York (above p.354). As has been discussed elsewhere (above p. 365 and in press), this assemblage, with other introduced species, probably first achieved a cosmopolitan distribution in Western Europe in the wake of the Roman military machine, which required the widespread transportation of vast quantities of grain to feed both its men and animals. Once established in a granary, these pests would be extremely difficult to dislodge, persisting today in the face of modern insecticides in grain residues in crevices and wall cavities, ready to infest any new supplies (Coombs & Freeman, 1955). In the Roman period, only

the burning of the granary to the ground would remove the fauna - and thereby create another destruction deposit. In the sewer beneath the legionary fortress at York, pests of stored products occurred in deposits ranging in date from the end of the second century to the late fourth (above p.354), and some livestock in his food must have been a fact of life for every Roman soldier, just as it was for sailors at least until the late eighteenth century (above p.361). Until effective legislation was introduced in this country after the First World War, a considerable degree of infestation in any grain store was regarded as inevitable (Munro, 1966); with no effective control measures and timber superstructures, the problem would have been much more acute during the Roman period. Although the insects could, to some extent, be removed by heating and manually before grinding, above a certain level of infestation grain becomes completely unpalatable and its food value is seriously impaired, a result of the build-up of uric acid waste products from the insects (Munro, 1966). The beetles in the Malton carbonised wheat layer were too poorly preserved for any estimate of the number of individuals per unit of grain to be attempted but, from the relative frequency of fragments in the rather battered sample, I would venture to suggest that the degree of infestation was moderate to severe, and that this is the most probable reason for the destruction of the deposit.

Discussion

The acceptance of insect infestation as the reason for the destruction of the wheat removes the necessity of finding a close historical context for this act, as Corder felt necessary, but it still leaves a number of questions unanswered. The destruction of small, and

occasionally larger amounts of infested corn must have been fairly commonplace at forts throughout the Roman period, if not an annual occurrence before receiving new stocks. Normally one would expect the material to be disposed of outside the fortified enclosure and this is perhaps the best explanation for the burnt grain recovered from outside the fort at Papcastle, Cumberland (Collingwood, 1913). At Malton, the destruction of the grain within the fort could be taken to suggest that at least part of the northern quarter of this rather large 3.4 hectare ($8\frac{1}{2}$ acre) enclosure was unoccupied at this period. Corder's trenches were, however, insufficient to show whether the carbonised wheat layer was a single deposit or composed of a whole series of overlapping heaps of slightly differing dates, and it remains possible that this area was used to dispose of grain residues over several decades.

If the carbonised grain is accepted as a single deposit, it is possible, employing Corder's figures for its extent, to arrive at some approximation as to the amount of corn consigned to the fire. Taking an average thickness for the layer as 0.2m. and an areal extent of 50m. by 90m., a volume of c. 90m.^{3}(118 cu.yds.) is obtained. Whilst in terms of the excavated evidence this might appear a rather high estimate, it must be remembered that the parts of the stack which were well oxygenated during combustion would be totally burnt and material sealed beneath some thickness of grain may have been completely unburnt and have subsequently decayed away. It remains, however, instructive to compare this minimal figure with the estimated capacity of one of the granaries in the Agricolan fort at Fendoch (Richmond & McIntyre, 1939). The 142m.^{3} (185 cu. yds.) capacity there suggested is considerably more than the amount of carbonised wheat implied at Malton but, allowing for a total combustion and other loss rating of over 25%,

we may tentatively suggest that the contents of one granary, as yet unexcavated, had gone sour and had to be destroyed at least once in the period 200-350. Although this would be a major loss to any garrison - the minimal estimate represents a year's supply for 236 men - and a greater one to those from whom the supply was exacted. it is a small amount when it is considered that in 1947 the United Nations Food and Agriculture Organisation estimated that 10% of World cereal production was lost annually by insect infestation (Munro, 1966); lacking insecticides and effective cleaning measures, losses in the third century must have been proportionally higher. One further problem which cannot be solved is why the grain, if unfit for human consumption, was not utilised or sold off for animal fodder, particularly when the extensive vicus outside the fort is considered (Mitchelson, 1964). The degree of infestation and threat to other supplies from the contaminated grain, however, may well have precluded this. Apart from passing references in Pliny (18,11,73) and Columella (1,6,12), there is no contemporary comment on grain infestation, but the effects of feeding corn with a high level of toxic microflora to livestock are well illustrated by a mediaeval document. In 1432, Thomas Sharp was indicted for selling to the Abbot of Colwick, Nottinghamshire, malt so "raw, recked and damaged with weevils" that it killed the hogs, hens and capons to which it was given (Salzman, 1923).

It is interesting to note that the carbonised wheat layer probably formed the basis for Richmond's (1955) suggestion that Malton acted as a collection centre for crops from the Farmlands of the Wolds. There is no other evidence to support this supposition and the amount suggested is less than a year's rations for a quingenary cohort garrison. The idea, however, is not inherently improbable since the fort is

situated by the River Derwent at the junction between the north-west corner of the Wolds and the southern end of the Howardian Hills, where there is ample evidence for intensive Roman farming activity (cf. Corder, 1932 & Stead, 1971), although no additional granaries, after the fashion of the Severan supply base at South Shields (Richmond, 1953) have been recorded within the fort.

A less restricted discussion of the history of the site during the third century, up to the rebuilding of the fort during the radical restructuring of the defences of the Province, initiated by the separatist emperor Carausius (287 - 293) and continued by the Constantinian House, can now be attempted. It may be questioned whether the fort was held at all or by only a caretaker garrison during the mid to late third century. The large fort lies in an area which, whilst apparently lacking large towns, had a considerably developed agricultural tradition with at least the beginnings of 'romanised' farms by the end of the second century (Stead, 1971). A large garrison - the size of the enclosure would imply at least a milliary cohort - in what was to all intents and purposes part of the 'Lowland Zone' appears as something of an anachronism during the period between the quelling of the presumed Brigantian revolt in the second half of the second century and the need for defence in depth from new threats along the eastern seaboard towards the end of the third century. Mitchelson (1964) has noted an absence of rebuilding in the civil settlement outside the fort during the third century, perhaps a result of the removal of much of its raison d'etre; this possibility is hinted at by Corder (1930) : "The occupation ..... was a prolonged and peaceful one, perhaps only partly military." There is some supporting evidence from other forts in the southern half of the county for abandonment or partial decay in the third century.

At Doncaster, the most southerly fort in the county, the limited amount of evidence for the period shows buildings being erected over roads, spreads of rough cobbling and the accumulation of occupation debris in which occurred a small hoard, more probably a loss, of bronze coins down to Gordian III (238-244) (Buckland & Dolby, in prep.). At Templeborough to the west (May, 1922; Simpson, 1973) and Castleford to the north (unpubl. material in Museum), the pottery series appear to virtually end in the early third century and these sites were probably abandoned as military posts. There is evidence for similar desertion at Vindolanda (Birley, 1974) and it has recently been suggested for sites along Hadrian's Wall (Gillam, 1974). It should not, however, be assumed that this implies a completely stable military situation after the Severan reorganisation but one which allowed some reduction in the number of troops in the Province. The problems on the Rhine frontier, beginning under Severus Alexander (ca.235), and requirements for bolstering up the separatist Gallic Empire (259-273) may have led to considerable troop withdrawals, despite the relative silence of our literary and epigraphic sources. Certainly Gallienus had stationed contingents, regarded by Mocksy (1974) as "probably of considerable strength", from both the British and Rhineland armies at Sirmium in Pannonia (C.I.L.3228) and their return was impeded by the Gallic Empire after the revolt of Posthumus in 259. The wording of the Birdoswald inscription, as Collingwood (1931) noted, sounds not like less than ten years neglect but longer and, although the old cohort names continue on the Wall in the fourth century, Wilkes (1966) has suggested that the returned units were somewhat smaller, although the coin evidence does not support this hypothesis (Casey, 1974). It is equally probable that Carausius, provided the northern frontier was relatively stable, had withdrawn forces, particularly in 288, when

invasion by Maximian from the Continent seemed imminent. If we are to accept an organised attack from north of the Wall, there is a certain lack of logic and remarkable coincidence in the assumption that it came in 296, when for nearly ten years previously most eyes and forces had been directed southwards. It must be stressed, however, that none of the "destruction deposits" in the northern forts can be absolutely dated to 296 and all rests on assumption. It is therefore necessary to review the excavated evidence for destruction in so far as it is published and to discuss what traces a barbarian invasion might leave in the archaeological record before yet another interpretation can be proposed.

Destruction deposits in the North of England

The evidence for destruction in the forts, milecastles and turrets along Hadrian's Wall has recently been discussed (Breeze & Dobson, 1972) and, rather than reiterate some of their conclusions, these sites will not be re-examined here; it is sufficient to state that irrefutable proof of enemy action has yet to be found.

Frere (1967), admitting the inadequacies of archaeological reports, suggests that .... "destruction... can be assumed with any degree of confidence only where the reports speak of widespread signs of fire". It would, however, be naive to uncritically accept such evidence as indicative of barbarian sack. In any settlement where structures are primarily of timber with wattle and daub infilling, even where stone or tile was used for roofing, the risk of accidental fire was always high and, in the relatively confined space of a Roman fort, it would be extremely difficult to stop fire spreading from one structure to another; perhaps if the practical student of Roman studies was more familiar with

the speed with which the Great Fire spread through the City of London in 1666 and the difficulties entailed in its curtailment, he would then be more circumspect in his interpretation of burnt layers. It should be further noted that there were serious fires in York in 1069 and 1137, the former the result of enemy action, when most of the city is thought to have been destroyed; neither has been satisfactorily traced in the archaeological record. Apparently extensive traces of burning need not relate to the same incident, since it is seldom that sufficient contiguous area within a fort has been cleared to prove that the deposits relate to one incident rather than several of slightly different date. Where a burnt layer has been attested as widespread on a site, the interpretation remains a matter of some difficulty and speculation. The frequency of accidental fires has been stressed above. Perhaps the most salutary comment is a near contemporary one: Frontinus, writing of Rome under Trajan, has, "nam et colles sensim propter frequentiam incendiorum excreverunt rudere" - for the hills have gradually grown higher with rubbish in consequence of frequent conflagrations" (Loeb Text, 1950); Rome did not suffer extensive enemy action between the sack by the Gauls in 391 B.C. and that by Alaric in A.D.410 and the deliberate and systematic destruction of buildings did not occur until 1084 when the city was taken by the Normans (Lanciani, 1899). Whilst the possibilities of accidental fires might be thought greater in a major city, every fort possessed at least one major fire risk in its granaries. The inflammability of civil horrea was recognised and a law of A.D.326 (Codex Theodosius, 15,1,4) lays down that an area one hundred feet wide be kept clear of buildings (Rickman, 1971); such isolation was impractical in the confined space of a military establishment. The risks from internal heating of stored grain were minimised by ventilation, the raised floor of the granary and probably ample louvres

in the sides of the structure (Bulmer, 1969), and protection from external fire hazards was provided by a stone or tiled roof. The risk of fire, however, must always have been high and it is therefore somewhat surprising to note that some German forts have a room with hypocaust attached to one end of the horrea (c.f. Weissenburg, Rickman, 1971), although it must be stressed that materials other than grain would be stored. The relative inflammability of granaries must be taken into account when burnt horizons are interpreted. Despite this, Hartley (1966), at Ilkley, regarded the burning down of the granary whilst still containing corn "almost certainly (to) be attributed to enemy action", a convenient literary date being provided by 196, yet at least one building within the fort may have continued into the later Severan period (op. cit.).

A direct comparison with evidence for major accidental fires in a period with better documentary records is hindered by the differing types of site and structural techniques. As Richmond (1961) has discussed, the timbers of the framework of many Roman timber framed buildings were sunk deep in the clay walling, unlike similarly constructed mediaeval houses, and this reduced the fire risks. The figures for the incidence of major fires in post-mediaeval Wessex (Jones, 1968), however, provide a parallel with which to drive home the need for caution in interpreting burnt horizons. In the decade 1670 - 79, there were fifteen major fires, destroying a minimum of ten houses plus attendant buildings in each, in the towns and villages of Berkshire, Dorset, Hampshire and Wiltshire. Had this destruction been represented by archaeological rather than documentary evidence, a further margin of at least ten years would have to allowed either side of this decade since it is rare that artifacts provide a date in such a narrow range; for the period 1660 to 1689 therefore, a total of thirty-two

major fires is recorded for this area, an archaeological possibility of as many destruction deposits in a relatively restricted region. With only a literary hint of Monmouth's rebellion in 1685, what would the interpretation be? The almost total destruction by fire of Blandford, Dorset, in 1731 can be contrasted with the slight traces of damage in Roman Silchester, which caused Boon (1974) to hint that the town might have suffered in the conflict between Allectus' and Asclepiodotus' troops in 296. Direct analogy remains impossible but the comparison serves as a cautionary tale of the frequency of accidental fires.

The Archaeological Evidence

At the risk of overstating a case, the excavated evidence from the military sites in the North must now be reviewed.

Figure 100. Roman sites in the North of England discussed in the text.

1. Carlisle (Luguvallium)
2. South Shields (Arbeia)
3. Ebchester (Vindomora)
4. Lanchester (Longovicium)
5. Chester-le-Street (Concangium)
6. Binchester (Vinovium)
7. Kirkby Thore (Bravoniacum)
8. Brough under Stainmore (Verterae)
9. Bowes (Lavatrae)
10. Greta Bridge (?Maglona)
11. Piercebridge (?Magae)
12. Ravenglass (Glannaventa)
13. Brough by Bainbridge (Virosidum)
14. Catterick (Cataractonium)
15. Aldborough (Isurium Brigantum)
16. Lancaster (Olenacum)
17. Ribchester (Bremetennacum)
18. Elslack
19. Ilkley (Olicana)
20. Newton Kyme
21. Brough-on-Humber
22. Manchester (Mamucium)
23. Doncaster (?Danum)
24. Templeborough
25. Brough-on-Noe (Navio)

Malton (Derventio)
York (Eburacum)
Chester (Deva)
Lincoln (Lindum)

Latin names from the fourth century Notitia Dignitatum, after Frere (1967).

Circles - major settlements (towns) Squares - forts.

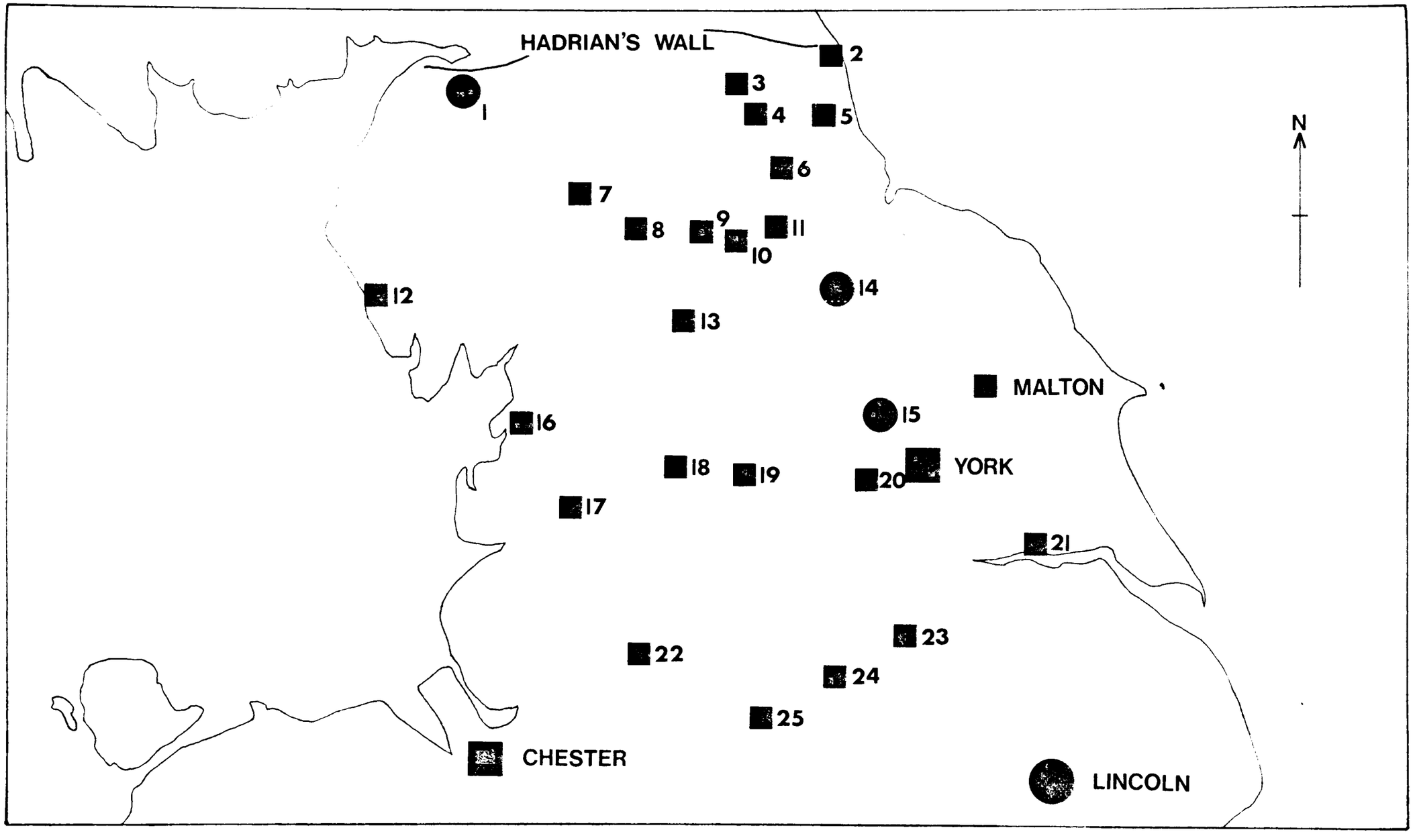


Figure 100. Roman sites in the North of England, discussed in the text.

Chester

Whilst the amount of excavation work which has been carried out in Chester remains insufficient to support the conclusions drawn from it, the growth of the idea of destruction in 296 provides an interesting side light on archaeological assumption rather than deduction. The primary source is the report by Richmond and Webster (1951) on excavations within the legionary fortress in Goss Street in 1948-9. In view of the inferences drawn in later papers, the relevant passage is worth quoting in full:

> "Until stratigraphical evidence from within the fortress is forthcoming it will be unwise to attach an exact date to the rebuilding; but it is obviously far closer to the period of disaster in A.D.296 than to the Maeatian destruction of A.D.197..... the evidence showed that the reconstruction (preceding 296) of the fortress, though drastic when it came, was a routine affair belonging to the twenties of the third century, a time when a good deal of activity of the kind is attested in the military area of northern Britain."

This appears a fairly reasoned account, although it should be noted that the only satisfactory dating evidence is the terminus post quem provided by the tombstone (R.I.B.488) of the time of either Caracalla (212-217) or Elagabalus (218-222) incorporated in the north wall of the fortress (op. cit.). By 1953, Webster, referring back to his joint (1951) paper with Richmond, felt able to write,

> "The rebuilding of the north wall with the help of tombstones robbed from nearby cemeteries now dated to the close of the third century ...."

It is apparent that Richmond also accepted this interpretation (1958, above, p. and Collingwood & Richmond, 1969), although other workers were more cautious. No. 'destruction deposits' were claimed in the praetorium (Petch, 1968) and, whilst the granaries appear to have been demolished in the late third century (Petch & Thompson, 1959), the interpretation of the evidence is more tentative:

> "It is conceivable that the demolition apparent in the excavations could be interpreted as deliberate destruction by invading barbarians; on the other hand, as a result of the military measures initiated by Diocletian and Constantine, the fourth century fortress must have altered greatly in appearance."

The tenet of destruction in 296 at Chester, although not examined critically, seems to have been quietly laid to rest and it is not referred to by Petch (1969) in his discussion of the fortress.

There remains, however, the problem of the interpretation of the north wall, which, with the western defences of the fortress (Thompson, 1969), was rebuilt and doubled in thickness at some date after ca.210, probably towards the end of the third century or a little later. Discussion may again be prefixed by a quotation, this time from the most recent publication on the legionary fortress (Petch, 1971):

> "In any case the rebuilding was done in a hurry, for the stone masons used many tombstones from the fortress cemeteries for their work."

This would imply that the sacrosanct nature of gravestones was recognised in the Roman World, and their use in construction work would only occur in a dire emergency. A certain degree of sanctity might be expected but it is doubtful that this would last long in a military establishment with few surviving relatives of the deceased. The reuse of stone coffins has been argued to reflect a change in attitude towards the dead during the fourth century (Ramm, 1971) but, as Richmond (1950) has eloquently pointed out (quoted above, p.378), one must take care not to impart modern ideas to ancient man. The polyglot nature of pre-Christian religions also makes generalisation hazardous. Certainly the builders of the Arch of Constantine did not hesitate to utilise tombstones from the cemeteries of two of Rome's senior families, the Fabii and the Aruntii (Lanciani,1899) and, the reuse of mediaeval tombstones in churches is widespread. No one would argue that the crypt of Doncaster parish church, vaulted almost entirely with decorated coffin lids, (Jackson, 1853), reflects work carried out in haste. The same has to be said for Roman Chester.

York

Although there has been a considerable amount of excavation work carried out in the city, relatively little is known in detail of the legionary fortress and the conventionally accepted sequence for the defences still rests on very tenuous foundations (Stead, 1968). Even less is known of the colonia. Butler (1971), discussing the reconstruction of the defences supposedly after the events of 296, comments,

> "This destruction .... is the best explanation for the widespread rebuilding required at York - if it is assigned to Constantius - although the direct evidence of the burning of buildings within the fortress is still lacking."

Traces of fire in the headquarters building below the Minster have been regarded as evidence for destruction in the late third century (Wilson, 1968; thence 296 in Collingwood & Richmond, 1969), but the full publication of the evidence must be awaited before much comment can be passed.

If the extensive and grandiose rebuilding of the south-west frontage of the fortress (R.C.H.M., 1962) had much practical rather than political significance, a rebuilding which incorporated projecting polygonal bastions for artillery of the most advanced form, then it is most curious, considering that the fortress is alleged to have fallen shortly before to an assault from the North, that the naturally best defended side should be afforded this additional protection, already covered by a steep fall to a large river, whose south bank was occupied by a large civil settlement, presumably walled. On the other three sides, most vulnerable towards the north, no attempt to provide for artillery on a large scale has been discovered and the defences continued with small, internal rectangular towers. The contrast with the strictly functional arrangement of the artillery platforms constructed earlier in the third

century at the outpost fort of High Rochester (Richmond, 1940) in Redesdale is to be noted. Whilst Miller's (1925) contention that the sides of the fortress away from the Ouse were protected by marsh and forest cannot be substantiated, there may be a slight element of truth in his further statement, ...

> "By the end of the third century, it would be more than ever the critical front, for it now had to face a new danger by water - dubiis venturum Saxona ventis."

Although the rebuilding can hardly be regarded as meeting a direct threat from maritime raiders, an event, best countered, as in the mediaeval period, by drawing a chain across the river, the impression, as Butler (1971) notes, created by the monumental frontage of permanence and power could have a deterrent effect on any recalcitrant, prospective raider or their contacts visiting York in trade or other business. The fortress probably acquired a certain myth of impregnability, perhaps best parallelled by that attained by Constantinople in mediaeval Europe. If, however, we are to seek a strictly practical interpretation of the fourth century defences, then some similar provision may be sought along the much lower waterfront of the colonia.

Frere (1961) has summarised the York evidence:

> "in the absence of destruction deposits we should perhaps assume that the neglect of a century, the presence of an Emperor and the inauguration of a new command were sufficient motives for grandiose reconstruction."

Binchester, County Durham

This site has, again, suffered little excavation and Steer's (1937) work before the last War remains unpublished. Limited excavation in 1955 (Dobson & Jarrett, 1958) revealed a structure interpreted as a ballista platform attached to the fort wall and, by analogy with a

similar structure at Chesterholm, this was ascribed to -

> "the visit to Britain of the Caesar Constantius Chlorus in 297 and the rebuilding which followed."

The only supporting evidence is a flanged bowl of Gillam type 227, dated to A.D.200 - 300 (Gillam, 1970) in the filling.

Ebchester, County Durham

Whilst relatively little excavation has been carried out on this site, the interpretation (Jarrett, 1960) shows how deep seated the tradition of events in 296 and thereafter had become. There were no definite destruction deposits referred to but, on the rather slight evidence of a small amount of pottery, any rebuilding in the fort, where a late third or early fourth century date is implied, is "dated to the Constantinian reconstruction of c.296." In the absence of inscriptions such precise dating cannot be upheld.

Lanchester, County Durham

Excavations were carried out shortly before the last War by Steer (1937) but these have not been published in detail. It is apparent from the excavator's report on the coarse potter (1939), however, that 296 was regarded as the closing date for the second major phase of occupation, although insufficient area was examined to support such sweeping generalisation.

Piercebridge, County Durham

Despite a scatter of earlier pottery and an inscription attesting a military presence in 217 (Birley, 1967), the large fort partially

examined, of c. 11 acres, appears to have been founded in the late third or early fourth century (Keeney, 1939). The exceptional size has caused one of its more recent excavators (Harper, 1968) to suggest that the fort was Constantius' base for his northern campaigns of 306, a retreat after the manner of Diocletian's palace at Spalato on the Dalmatian Coast. In size, however, it only slightly exceeds both Malton and Newton Kyme and on the Continent it is parallelled by the similarly dated fort, perhaps for Legio I Martia, at Kaiseraugst, near Basle (Schönberger, 1969). The coin list from the site is slight and the assumption of a Constantinian date is unsupported by the only errefutable line of evidence, the epigraphic. It is well to remember that, like ^{14}C dates, a standard deviation exists with the archaeological evidence and the drifting date of the Saxon Shore fort at Richborough (Cunliffe, 1968; Johnson, 1970) is salutary; late third to early fourth century covers the period c. 275 - 325, if not more.

South Shields, County Durham

The absence of any deposit capable of interpretation as evidence for destruction by enemy action on this fort site excited comment and explanation from its excavators:

> "It seems that successive land invaders who overwhelmed the Wall swept across it without turning aside to attack or sack the stores establishment at South Shields and its remoteness from the main lines of penetration saved it" (Richmond, 1953).

Subsequent work (Breeze, 1970) has shown that the fort only functioned as a stores base during the Severan campaigns in Scotland, perhaps for less than ten years, and the additional granaries were converted to barrack accommodation after only a short life. Practically, South Shields, with twenty-two granaries, represented the greatest fire risk in a fort in the North and the absence of destruction by fire, at least in part,

comes as something of a surprise, probably a factor of its short term use as a stores depot. Richmond's contention that the fort was remote from the "main lines of penetration" is difficult to counter since we have little idea where such hypothetical lines might lie but any organised attack - and anything less would surely not be in the position to take fort after fort - over the eastern sector of the Wall could not afford to leave South Shields at its back in its headlong rush southwards for richer booty, to harrass withdrawal and serve as a base for counter-attack. Neither is it certain that the fort can be regarded as remote. Morris (1965; 1973) has suggested that the Yorkshire signal stations of the later fourth century were constructed primarily against maritime Pictish raiders and the mouth of the Tyne would, in any case, be as good a landfall for Saxon raiders as it was for Viking four hundred years later.

Dobson (1969) provides the most recent summary of the evidence from Roman County Durham ...

> "None of the Durham sites has produced evidence for or against destruction."

Lancaster

During excavations in 1950, Richmond (1954) was able to show that the surviving fragment of Roman walling, known as the Wery Wall, formed part of the enceinte of a fourth century fort, which he related to the military reorganisation under Constantius after 296. More recent work (Wilson, 1975) has produced a slightly worn coin of c. 326 from its construction level. There is no evidence for Richmond's contention (op. cit.) that, "It is clear that the West Coast in general had been more severely harried in the disaster of 296 than in that of A.D. 197"; as Jarrett (1969) has already suggested the evidence for the latter is equally vague.

Watercrook, Westmoreland

Birley (1958) has summarised the evidence from the site of this fort, presuming that it underwent "the same series of destructions and reconstructions as has been revealed by excavation in many forts on Hadrian's Wall or in its hinterland"; the evidence from the small scale excavations, however, only revealed one post-Hadrianic phase of reconstruction (op. cit.). More recent work (Wilson, 1974) has yet to be published in detail but a late third century rebuilding of part of the enceinte is suggested and the date for the abandonment of the area of the vicus examined put at ca. 300.

For other sites in the North, there is either insufficient evidence for comment or the excavators have been more cautious in their interpretation. These sites, with principal sources, are listed below, although the list does not claim to be exhaustive.

1. Other forts with some stratigraphic evidence for construction or extensive rebuilding in the late third or early fourth centuries:

Brough-on-Noe	(Jones, 1968)
Burrow-in-Lonsdale ?	(Hilyard, 1955)
Doncaster	(Buckland & Dolby, in prep.)
Elslack	(May, 1911; Frere, 1967)
Greta Bridge	(Wilson, 1975 - vicus)
Ilkley	(Hartley, 1966)
Manchester	(Jones & Grealey, 1974; Simpson, 1973)
Papcastle	(Charlesworth, 1964)
Ribchester ?	(Atkinson, 1928)
Templeborough?	(Simpson, 1973)
Watercrook	(Wilson, 1975)

Newton Kyme, Piercebridge and Malton, at between 8 and 10 acres, are as large as the Diocletianic or Constantinian legionary fortress at Kaiseraugst (3.6 hectares, c. 9 acres), near Basle (Schönberger, 1969), and it may be questioned whether VI Victrix now formed part of the field army of Britain, split between these large forts and York.

2. The following sites have produced no evidence which has been, or can be, interpreted as the results of destruction in 296.

Aldborough	(Charlesworth, 1971)
Brough on Humber	(Wacher, 1969)
Brough by Bainbridge	(Hartley, 1963)
Catterick	(Hilyard, 1958; Wacher, 1971)
Doncaster	(Buckland & Dolby, in prep.)
Ilkley	(Hartley, 1966)
Old Durham	(Richmond et al., 1944)

3. Insufficient evidence for comment has been recovered from:

Brougham	
Bowes	(Wilson, 1971)
Brough under Stainmore	(Birley, 1958a)
Burrow-in-Lonsdale	(Hilyard, 1955)
Carlisle	
Chester-le-Street	(Rainbird, 1971)
Kirkby Thore	(Charlesworth, 1964)
Manchester	(Petch, 1954; Jones & Grealey, 1974)
Papcastle	(Collingwood, 1913)
Ravenglass	(Birley, 1958b)
Ribchester	(Atkinson, 1928)

Conclusions

With such an apparent wealth of excavated evidence, it is difficult to accept that no satisfactory interpretative model, synthesising the data, can be propounded. In the opinion of the author, no conclusive demonstration of destruction in or about A.D. 296 has yet been published from any site in the north of England. In Cambridgeshire, Green (1975) has claimed that the small town of Godmanchester was destroyed 'towards the close of the third century', citing extensive burning and a scatter of human bone gnawed by animals. The site has not been published in detail and many of Green's (op. cit.) other conclusions about the site contain a degree of exactitude wholly out of keeping with the nature of the archaeological evidence (c.f. his use of the environmental data (op. cit.)). This, however, is not to deny that destruction may well have taken place on some sites but, short of the graphic evidence of war cemeteries like that within Maiden Castle, Dorset (Wheeler, 1943), or the clearly butchered dead lying within destroyed buildings as in mediaeval Kiev (Mongait, 1961), it is doubtful whether archaeological methods are capable of recognising destruction, of distinguishing between natural and man-made disasters or separating site clearance before rebuilding from the activities of hostile hands. Abandonment and decay, however, may be recognised, particularly with regard to changes in the environmental evidence and, on sites with good waterlogged successions like Vindolanda (Birley, 1974), the insect evidence can chart this progress, although there are few sites where the standards of excavation are sufficiently high or where the time is available for the necessary meticulous techniques.

Dispensing with destruction, the evident redistribution of troops still requires explanation. The extent of Contantius Chlorus' campaigns in the north in the early years of the fourth

century is unknown and may relate to events wholly beyond the frontier, a minor punitive expedition, seized upon by a panegyrist to provide a further element of military glory. The reoccupation of such remote Pennine centres as Elslack (May, 1911; Frere, 1967) and lowland forts like Doncaster, might suggest problems of internal security rather than external threat, although there is clearly an element of this along the Saxon Shore and perhaps on the West Coast. Problems with a recalcitrant colonate are less likely to appear in the pages of a semi-official biographer or one conscious of his own position within the state than a campaign against external aggressors. Thomson (1952) has discussed similar events in late Roman Gaul and Iberia and his conclusions may be relevant to Britain. In the lowland part of the Island, the system of small, fortified strongpoints along Watling Street (Webster, 1975) may relate more to policing problems with the local populace than to Chlorus' campaign of reconquest in 296, for which they seem too substantial. It has also to be considered, however, that a standing unoccupied army poses a threat in itself to security, particularly to a caesar, in Constantine, proclaimed by part of it and intent on the elimination of the other members of the Empire's insecure tetrarchy, and the dispersal of less reliable units in the British army to man isolated forts would be a necessary prelude to crossing to the mainland and a process frequently adopted throughout the history of the Empire.

Perhaps an admission that we know rather less about the pattern of events in Roman Britain than we prefer to believe would be the most honest way of terminating this study.

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